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Pielou and Proverbs—Diazinon: A summary of recent work on a new orchard insecticide - - - - - - - - - - - - 3

Gregson—Tick paralysis in cattle in British Columbia in 1957 - - 6

Spencer—The insects attacking structural timbers and furniture in homes in coastal British Columbia - - - - - - 8

Zuk—Distribution of stored food insects in British Columbia - - 13

Pielou and Downing—Trithion as an orchard insecticide - - - 17

Touzeau and Neilson—Eradication procedures for oriental fruit moth in the Okanagan Valley of British Columbia - - - 23

Grant—Observations on a pine shoot moth, *Eucosma sonomana* Kft. (Lepidoptera: Olethreutidae) - - - - - - - - - 26

Hardy—Notes on the life histories of three species of Lepidoptera from southern Vancouver Island, British Columbia - - - 27

Ross—A list of cone and seed insects of interior British Columbia - 30

Ruppel—A brief history of larch sawfly, *Pristiphora erichsonii* (Htg.), in British Columbia - - - - - - - - - - - 32

Scudder—A new aspect on the faunal connections between Europe and the Pacific Northwest - - - - - - - - - 36

Hedlin—Insects causing seed losses in Douglas fir on Vancouver Island in 1957 - - - - - - - - - - - - 37

Ross and Evans—Annotated list of forest insects of British Columbia Part VIII — *Semiothisa* spp. (Geometridae) - - - - 40

Science notes - - - - - - - - - - - - 16, 25, 26, 35, 39

Book review - - - - - - - - - - - - - - - - 41

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Hardy—Notes on the life histories of three species of Lepidoptera from southern Vancouver Island, British Columbia - - - 27
Ross—A list of cone and seed insects of interior British Columbia - 30
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Scudder—A new aspect on the faunal connections between Europe and the Pacific Northwest - - - - - - - - - 36
Hedlin—Insects causing seed losses in Douglas fir on Vancouver Island in 1957 - - - - - - - - - - - - 37
Ross and Evans—Annotated list of forest insects of British Columbia Part VIII — *Semiothisa* spp. (Geometridae) - - - - 40
Science notes - - - - - - - - - - 16, 25, 26, 35, 39
Book review - - - - - - - - - - - - - 41

DIRECTORS OF THE ENTOMOLOGICAL SOCIETY OF BRITISH COLUMBIA FOR 1958-59

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DIAZINON: A SUMMARY OF RECENT WORK ON A NEW ORCHARD INSECTICIDE[1]

D. P. PIELOU and M. D. PROVERBS[2]

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This paper is an interim report summarizing, up to the present, the main findings of the Summerland Laboratory on the insecticide Diazinon.

Diazinon (Geigy Agricultural Chemicals, 1956) was introduced recently by the Geigy Company of Switzerland, the firm that produced DDT and, therefore, largely initiated the modern era of pest control. Apparently Diazinon was obtained in a search for an insecticide that would control DDT-resistant house flies; such a material besides having high insecticidal action, must have good residual action (on inanimate surfaces at least) and relatively low human toxicity.

Chemically, Diazinon belongs to the phosphoric acid ester group of enolisable heterocyclic systems. Described chemically as 0, 0-diethyl 0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate, it is unusual in containing a pyrimidine, or 1, 3 diazine ring (a cyclic configuration of four carbon and two nitrogen atoms) together with an isopropyl and a conventional organic phosphate group. The expense of adding the pyrimidyl group leaves some doubt as to whether the price of Diazinon can be made competitive with other orchard insecticides. At present the technical chemical is imported from Switzerland and only the formulation is done in the U.S.A.

The data available on the toxicity of Diazinon to man and animals suggest that it is more toxic than malathion, but less toxic than parathion or TEPP, for example. According to Swiss workers (Buxtorf and Spindler, 1954), results on rats show that, by oral administration, parathion is about 60 times as toxic as Diazinon (so that Diazinon is approximately equal in toxicity to DDT). Malathion is almost harmless to rats, being about one-tenth as toxic as DDT or Diazinon. However, with week-old calves, U.S. Department of Agriculture workers (Radeleff *et al.*, 1955) obtained less promising results. Parathion, by oral administrations, was found to be twice as toxic as Diazinon, Diazinon 20 times as toxic as malathion, and malathion itself twelve times as toxic as DDT. DDT, as far as calves are concerned, is the least harmful material. The fact that DDT and malathion are reversed in sequence of toxicity, as between rats and calves, shows the difficulty of extrapolating such results to man and other animals on the basis of weight. Further, when the toxic action of dermal sprays on calves is considered, somewhat different figures hold. Parathion is then ten times as toxic as Diazinon, and Diazinon ten times as toxic as malathion. The last figures are probably the most valuable. In the surface-to-weight ratio calves are more like men than rats, and danger in the orchard is more likely to come from dermal effects than from oral ingestion.

One of the main points in favour of Diazinon as an orchard insecticide is that we have never observed any phytotoxic effects with either wettable powders or emulsions, even at much higher concentration than would ever be used in practice. And the likelihood of spray damage is a major aspect to consider in the introduction of a pesticide. We have not yet tested Diazinon against a full range of fruit varieties, in particular, against yellow varieties of apples, in which there are reports from elsewhere (Buxtorf and Spindler, 1954) of slight damage. As an example of our own results we

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may cite a comparative test of malathion, a material that is particularly likely to damage cherry, and diazinon. Malathion applied with a high-volume gun sprayer at eight pounds of 25 per cent wettable powder per 100 gallons (four times normal concentration) caused severe injury to cherry, moderate injury to apricot, and slight injury to peach. At double that strength the result was death, severe injury, or total defoliation to all soft fruits except prunes. But Diazinon at 30 pounds of 25 per cent wettable powder per 100 gallons (*i.e.* 15 times the recommended dosage) did not cause noticeable fruit or leaf injury to any type of fruit tree, including cherry.

High residual action and stability are claimed for Diazinon when used on walls. On living plant tissue the residual action is not necessarily the same. In lieu of specific chemical tests of deposit decline, long term action is demonstrated by satisfactory control of some insect for which effective coverage is necessary over an extended period. The codling moth, *Carpocapsa pomonella* (L.), the worst orchard enemy in British Columbia, is the best example of such an insect. A comparison was therefore made in 1955 by Dr. J. Marshall (unpublished) of the Summerland laboratory, using paired trees in an orchard heavily infested with the moth; one tree of each pair was sprayed with 50 per cent DDT wettable powder at 1.5 pounds per 100 gallons (12 ounces of active ingredient), the other with 25 per cent Diazinon wettable powder at two pounds per 100 gallons (8 ounces of active ingredient). Seven tree pairs were used. Two cover sprays were applied against the first brood and one against the second brood. At the end of the season the percentage of wormy fruit were: DDT, 12.9; Diazinon, 12.4; unsprayed checks, 79.1. In 1956 further trials were carried out in another heavily infested orchard. In this instance a concentrate sprayer was used, and four cover sprays of 25 per cent Diazinon wettable powder were applied at nine pounds (2.25 pounds of active ingredient) per acre. For a comparison, 50 per cent DDT wettable powder was applied at six pounds (three pounds of active ingredient) per acre. Both these rates are somewhat lower than would be used commercially. At harvest time the percentages of wormy fruit were 10.7 in the DDT plot and 4.8 in the Diazinon plot. In view of the high infestations in both orchards, and the concentrations of active ingredients that were used, there is no doubt that Diazinon was at least as effective against the codling moth as DDT. In the latter orchard the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), was also abundant and the percentages of fruit showing typical injury by this pest at harvest time were: DDT plots, 10.1; Diazinon plots, 0.8. In another orchard 25 per cent Diazinon was applied as a single dilute spray at two pounds per 100 gallons against the bud moth on apple and cherry trees; control was nearly perfect.

A special point of interest with Diazinon is the very wide range of orchard pests that it is effective against. Particular insecticides often prove to be effective against a particular group of insects — soil or cotton insects, for instance. Up to the present there has been no single insecticide with a wide "spectrum" against orchard insects. DDT and parathion together, or DDT and malathion together, have been the nearest approach to this. Diazinon we consider to be an insecticide that will do all either of these combinations will do, and perhaps something more as well.

Diazinon is therefore a "general" insecticide. In the past, when entomologists in British Columbia were more concerned about hypothetical dangers from the destruction of parasites or predators, they were more prone to recommend selective insecticides as a safeguard. It appears to the authors, however, that disharmony (sufficient to cause economic loss) between chemical control and natural control of insects by indigenous enemies has been overstated, at least under the conditions of the semi-arid

British Columbia interior. Further, biological control with introduced parasites plays a minor part among all but two orchard pests in this part of British Columbia. There is, therefore, a lessening of interest in British Columbia in highly selective insecticides (which mean a multiplicity of materials and costs) and a revival of interest in more general insecticides that promise cheaper, or, at least, simpler spray schedules; this point of view is readily appreciated by the grower.

The effectiveness of Diazinon against the codling moth has already been mentioned. This is important from another aspect. Resistance to DDT, which was developed quickly in species like house flies. is, after a longer period of grace, beginning to appear in the codling moth. In one area of Australia it is extremely high (Smith, 1955); it is noticeable in parts of the eastern U.S.A. (Clancy, 1955) and there are reports of measurable increases in resistance from Washington State. It may be expected in British Columbia in time. Diazinon appears to be an answer.

Against aphids, both on apple and on stone fruits, the material is excellent. At one or two pounds per 100 gallons perfect control has been obtained against the black cherry aphid, *Myzus cerasi* (F.); the green peach aphid, *Myzus persicae* (Sulz.); the mealy plum aphid, *Hyalopterus pruni* (Geof.) [= *H. arundinis* (F.)]; the thistle aphid, *Anuraphis cardui* (L.); the woolly apple aphid, *Eriosoma lanigerum* (Hausm.); and the apple aphid, *Aphis pomi* Deg. Against the black cherry aphid, Diazinon seems to have a special place, because malathion readily damages cherry, parathion is not recommended because of toxicity to human beings, lindane is apt to taint the fruit, and nicotine is often ineffective at low temperatures early in the season when spraying is necessary. Even if a grower has failed to spray early in a season, when other aphicides are most valuable, he can get adequate control of the black cherry aphid with a summer application of Diazinon even though the aphids are then protected by the tightly curled foliage. Similarly, the green peach aphid was perfectly controlled in 1954 with Diazinon, in an orchard where malathion had earlier proved unsatisfactory. With the apple aphid, however, re-infestation from neighbouring orchards is a constant problem and against that species Diazinon has been no better than malathion or lindane. Under the severe aphid attacks of 1955 and 1956 repeated spraying was, therefore, necessary with Diazinon as with other materials. In commercial orchards it is expensive to apply insecticides repeatedly for aphids only. However, if the insecticide is used for other purposes (*e.g.*, Diazinon for the codling moth cover sprays), repeated application may be economically feasible.

Diazinon gives good control of overwintered nymphs of soft scales, *Lecanium* spp., on peach and apricot. It is also effective as an early summer spray against the San Jose scale, *Aspidiotus perniciosus* Comst.

Against orchard mites, Diazinon, in a single application, has given very good results against the active stages of the clover mite, *Bryobia arborea* M. & A. (*B. praetiosa* of authors, in part); the European red mite, *Metatetranychus ulmi* (Koch); the yellow mite, *Eotetranychus carpini* (Oudms.) [=*E. carpini borealis* (Ewing)]; the McDaniel spider mite, *Tetranychus mcdanieli* McG.; and the apple rust mite, *Vasates schlechtendali* (Nal.) (Downing, 1957). However, residual control is not so good as with specific miticides. But if Diazinon were applied in the repeated cover sprays for codling moth control, growers would probably be little concerned with mites unless phosphate-resistant strains of the European red mite were present. Diazinon is not effective against such mites. At the present they pose a major problem for which specific miticides are required. Apart from this, however, Diazinon has an advantage over specific miticides in that most of them have a tendency to dmaage foliage.

We have done no tests with Diazinon against the rosy apple aphid, the pear psylla, "cat facing" bugs, or cherry fruit flies, but results from elsewhere indicate that Diazinon is very effective in these cases.

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TICK PARALYSIS IN CATTLE IN BRITISH COLUMBIA IN 1957[1]

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Several serious outbreaks of tick paralysis in cattle were caused by the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, in the Nicola-Kamloops area of British Columbia in the spring of 1957. These were favoured by prolonged tick activity during a late spring, and by lack of, or inadequate, spraying of animals with BHC. Several rain showers also served to weaken residues that originally may have been sufficiently strong to afford normal protection from the ticks.

The first outbreak occurred on April 10 at the J. Lauder ranch, Merritt. Three hundred yearling cattle, which had not been bothered by ticks during the past three years and hence had not been sprayed, became infested with clusters of several dozen engorging ticks per animal. Ten were paralyzed in the field; three of these died. The remaining animals were rounded up and sprayed the following day with BHC at the recommended rate of 4 ounces of wettable powder (Ortho BHC 10 Wettable, 10 per cent gamma isomer; California Spray-Chemical Corporation, Portland, Oregon) per gallon of water.

On April 19, at Drew's ranch, Stump Lake, 32 yearlings in a herd of 118 became paralyzed. The herd, which had been sprayed with BHC wettable powder (Ortho BHC 10 Wettable) at 2 ounces per gallon of water two weeks previously, was resprayed; and stricken animals were deticked in the field and each given 600,000 units of penicillin to safeguard against pneumonia. Seven animals died.

The following day a large outbreak was reported by the Nicola Stock Company at what is known locally as the Saxon Field, about six miles up Quilchena Creek. This area has been heavily infested with ticks for many years, and in 1944, in a derris-sprayed herd of 1,230 yearlings, 400 were paralyzed and 50 were lost. In 1957, the herd had been sprayed with BHC, but at only ½ ounce of wettable powder (Ortho BHC 10 Wettable) per gallon of water, resulting in little residual protection. When the writer visited the area on April 21, nine cowboys were searching some ten square miles

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Some of 120 cattle that were paralyzed by ticks while being held overnight for treatment with BHC.

of rangeland for 200 paralyzed animals. Many of the cattle had collapsed in creek bottoms and underbrush and were suffering from exposure. The more advanced cases were completely immobilized; some had already been attacked by magpies and coyotes. Others were able to sit up. Their behaviours varied from glassy-eyed helplessness to complacency. As they were discovered the engorging ticks were combed off or doused with diesel oil. Most of the animals recovered by the following day, and only about 30 were lost. The remaining 500 unparalyzed but heavily infested animals were rounded up and driven four miles to the nearest corral. By next morning, when equipment was assembled for BHC spraying, 120 of these had become paralyzed. All these recovered completely although some were still unable to walk steadily two days later. Two were drowned while attempting to drink at a nearby lake. In addition to the total animal losses, the owner suffered losses from animal shrinkage due to movement and lack of food, and in wages for manpower.

Another outbreak occurred at the W. Davis ranch at Mammot Lake on April 26, when 14 yearlings in a herd of 70 became affected. All recovered after an emergency treatment of coal oil and crankcase oil, followed by a BHC spray. This was the first time that this rancher had cattle paralyzed by ticks during his thirteen years of ranching in this valley.

Summary

In 1957, four outbreaks of paralysis occurred in cattle from attacks by the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles, in the Kamloops-Nicola districts of British Columbia. In herds of 300, 118, 700, and 70 yearlings, 10, 32, 320, and 14 animals respectively were paralyzed, with losses of 3, 7, 30, and 0 respectively. The outbreaks were favoured by a combination of prolonged tick activity and insufficient protection from BHC sprays due to showery weather and inadequate dosage.

THE INSECTS ATTACKING STRUCTURAL TIMBERS AND FURNITURE IN HOMES IN COASTAL BRITISH COLUMBIA

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Arranging wood-eating and timber-destroying insects of coastal British Columbia in order of wideness of distribution and frequency of occurrence, we have: termites; carpenter ants; the golden Buprestid; the dry rot beetle; the anobiid *Hadrobregmus destructor*; the European furniture beetle; the longicorn *Opsimus quadrilineatus*; the powder post beetle *Lyctus brunneus*; the garden ant *Lasius niger* s. sp. and the wharf borer.

Termites

Three species of Termites are indigenous: *Zootermopsis angusticollis* (Hagen), the damp wood termite, found on the west coast of Vancouver Island, around Victoria and at Nanaimo, on the mainland coast from the international border to Prince Rupert, around Salmon Arm and Revelstoke and perhaps at Quesnel Lake; another damp wood termite, *Z. nevadensis* (Hagen), occupies much the same territory but less commonly; and *Reticulitermes hesperus* Banks, the subterranean or dry land termite, which occurs in the Dry Belt from Osoyoos, up the Okanagan Valley to Kamloops and from Lytton to Lillooet, on Vancouver Island on the eastern dry side from Victoria to Nanaimo and on some of the gulf islands.

Z. angusticollis is far more widespread than is generally recognized. It is particularly bad in townsites carved out of heavy timberland, such as Powell River, and in old logs on the coast that lie half embedded in sandy beaches, which serve as reservoirs from which flights emerge during August and into September.

The establishment of colonies of the two damp wood species apparently comes about by the winged reproductives spreading widely in all directions and coming down randomly against the sides of buildings where they may succeed in founding a colony in places where the wood is very damp or where damp earth is in contact with the sides of the house. All others not finding such areas of soggy wood, must perforce perish. Opposed to this theory is the supposition that males and females in flight detect from a height of hundreds of feet in the air, very limited areas of damp or rotting wood, and drop down to found colonies therein. This would seem to be beyond the powers even of these remarkable insects. The bases of old telephone poles are susceptible to termites, especially those that are surrounded by tall grass and weeds. I have one record, however, of a flourishing colony in a telephone pole isolated three feet above the ground where the insects were able to survive by the moisture maintained by rains beating into wide cracks in the pole. These insects require an almost saturated atmosphere in which to nest; given such conditions, they sometimes tunnel into solid dry wood as much as six feet from the damp nesting area, obtaining the necessary humidity by sealing up tunnels to produce dead air spaces. I have another record of a flourishing colony far removed from damp earth, where the termites were doing much damage to one of the upper floors in a 6-storey concrete warehouse; the floors were of 2 x 6-inch laminated planks and the infested floor must have been subjected to persistent, slow leaks either from pipes or the roof, to provide the decay in which the termites flourished.

Woodwork in dead-air crawl spaces beneath one-storey buildings, is very susceptible to termite infestation as is that in partly excavated basements and most particularly, the woodwork under enclosed front steps of stucco houses or the cribbing left behind by

builders under concrete steps leading up to houses. From colonies in such concrete-enclosed spaces, reproductives may emerge in swarms from exit tunnels cut for them by workers, through oak flooring in halls or through sills or walls on each side of the steps. Another susceptible point is woodwork behind brick planter-boxes up against buildings where moisture seeps through the bricks or when the metal boxes rust through several years after construction. Such colonies are difficult to destroy because it is so hard to reach them except by removal of the bricks.

Colonies of *Zootermopsis* in this region do not make earthen and frass tubes up the sides of buildings in order to cross concrete walls and to reach woodwork out of contact with the earth. Only once have I seen these tubes, three of them, over three feet long under the steps of a house where the insects had riddled all damp wood and were migrating sideways into a dry 2 x 6-inch sill and into dry 2 x 4-inch studs; the tubes had been dropped *downwards* from the dry wood to obtain moisture from the damp earth at the base of the wall. Two of the tubes had reached the earth and the third had almost reached it and was in process of being built when I examined it.

Sawdust bins in basements, made of ship-lap on 2 x 4-inch studding, holding wet, old, decaying sawdust, are often heavily infested with termites, even to the ¾-inch boards themselves. The infestation may spread even to the lath of stucco walls. I have a record of the north and east sides of a bungalow where all woodwork was so destroyed that daylight was visible through many parts of the walls; the joists and sills of the living room above were perforated and the front steps had to be replaced; the damage was estimated at $2000.

The best treatment for termites in this region is to replace all infested wood with new, treated timber and to spray the termites as they are exposed. Soil treatment is not necessary. If damage to beams is not very extensive and the colony is small, spray or dust can be blown in through holes drilled for the purpose. Since coastal species do not throw up tubes to reach wood lying above concrete walls, it is unnecessary to equip houses with angled metal stripping above the concrete or brick foundation walls. Damp earth touching wooden or stucco walls, leaking roofs and blocked tile drains are the chief causes of termite infestation and the first things that should be remedied.

Although slight damage to homes and other buildings is very widespread in Vancouver and severe damage is not uncommon, no houses have collapsed as yet in the city. In Victoria where all three species of termites occur, two houses have been reported to have collapsed and one each in Kamloops and Kelowna where only *R. hesperus* occurs.

Carpenter ants

Not so widely distributed as termites but causing very severe damage where they do occur, are carpenter ants, *Campanotus herculaneus* var. *modoc* M. Wheeler. They excavate tunnels in very dry wood remote from contact with damp earth *and* they are infinitely harder to get rid of than termites unless their nests can be located at once. They do not work in darkness or in an atmosphere of 95 per cent saturation as do termites, but they forage outside and thus reveal their presence, as they do by throwing out sawdust from the tunnels. Although they excavate very dry wood and have exits almost anywhere, the nests and nurseries are always in damp spots, sometimes of very limited size, such as may be produced by rain oozing through a nail hole or between a sill and the top of a concrete wall. The nests are usually difficult to locate and while they are often under window sills or in window and door frames, they may be in corner posts, studding of walls, floor joists, rafters, under hand split shingles or even between sub-flooring

and hardwood floors. In both small and especially in large houses, several nests may be present and ants may wander out into every room.

In log houses especially, carpenter ants may work for years without arousing suspicion, often chewing out soft, summer wood in concentric rings between the hard, winter check wood, until one side of the house begins to settle. By that time the only thing to do is to replace the logs one at a time starting from the bottom.

Colonies may start in several ways. In older houses in built-up areas, colonies generally start from overwintered "queens" that were fertilized on a marriage flight; such colonies take at least three years to become evident. Or a colony may become established in a house from long-piled firewood or from infested timbers salvaged from another building. Old stumps left in corners of hill-side homes often contain colonies and it is a matter of time before the ants move into the house itself especially if the stump is rooted up and the ants allowed to survive. When houses are being built on newly cleared soil long-established ant colonies may be disturbed and may move *en bloc* into the new houses. If the houses are of post-and-beam or Panabode type in which the tongue-and-groove lumber does not always fit tightly, ants may make runways sometimes the full length of a house. I have seen a quart of ant sawdust dumped into a switch box in a huge Panabode house that had been occupied less than six months; one could hear the ants rasping away all over the house.

When a large house is infested it is generally difficult to locate the nests without stripping off the stucco or sheeting. When nests cannot be located and the whole colony destroyed, it is necessary to put down a residual insecticide right around a house and to maintain it all summer, destroying the colony by attrition, a process that may take one whole season or even two. The feeding places of ants should be located by watching foraging workers which often get honeydew from aphids on Douglas fir trees or from the glands on the petioles of laurel bushes; the marching columns can be sprayed with three to five per cent chlordane.

Where colonies are known to be living in large beams, injections into the wood through drilled holes, of a 50-50 mixture of creosote and kerosene, will cause hordes of ants to pour out, when they can be sprayed. This is permissible in basements or in raw wood but in painted or papered walls which would be spoiled by the brown stain of crude creosote, it is better to use a solution of carbolic acid.

Golden Buprestid

For frequency of occurrence and wide distribution the golden Buprestid, *Buprestis aurulenta* Linn. ranks high, although it is rarely abundant enough to cause much damage. I have many records of emergences from buildings ranging from 5 to 50 years of age with most emergences coming in the 12 to 30 year range. The larvae of this beetle can persist in wood longer, I think, than those of any other insect in any other medium. In August, 1931, at Aspen Grove near Merritt, I cut up a pine tree of 8-inch diameter, into slices $\frac{3}{4}$ to $\frac{7}{8}$-inches thick and stacked them; *B. aurulenta* laid eggs in the topmost slice. The wood was brought to Vancouver in September and laid on a shelf in the laboratory; soon afterwards, very fine boring dust was thrown from minute tunnels in the infested slice. The slice was thin so the larvae moved from side to side of it throwing out sawdust at intervals until September, 1951, when we moved into another building and the larvae died, exactly 20 years after the eggs were laid and even then they were only one-third grown. The 50-year record concerned emergence of adults from pews in a church in Alberni, Vancouver Island. (4).

From one to five beetles only emerge from any one house of average construction, but in some log houses currently under observation, especially

one enormous residence built in 1931 of whole logs, thick slabs and thin stair posts, beetles emerge every year by the dozen. In 1957 one emerged from a banister as I was walking up the stairs. Everything points to females of this beetle laying eggs in crevices in recently cut timbers in log houses and larvae therefrom, developing in this slow-drying wood without having to feed for several weeks in the cambium layer as do the larvae of most buprestids. I have noted beetles running in and out of their own and former exit tunnels and from the scores of holes in one verandah post, I am convinced that eggs were laid in it over a period of years and larvae successfully developed in it.

Only two pieces of 2 x 4-inch wood have come to my attention which were absolutely riddled by larvae of this beetle, completely destroying them. Both larvae and beetles were recovered from this wood so there can be no question about the identity of the species. An intensive study of this beetle is long overdue.

Dry rot beetle

Also high in frequency of occurrence but of little consequence, is the anobiid beetle *Coelostethus quadrulus* (Lec.) which I have called the dry rot beetle. Dry rot is common in the lower Fraser Valley, especially in homes where tile drainage is blocked or absent and woodwork becomes damp. Sooner or later the diseased parts are discovered by this beetle, even small spots some two inches square in remote corners of a basement. Woodwork in damp, dead-air spaces almost invariably develops dry rot and equally surely this beetle infests the affected parts.

It is an effect, not a cause and of little consequence since it does not attack sound wood.

Hadrobregmus destructor Fisher

Also in houses, summer homes and lakeside log cabins, occur extensive perforations made by another anobiid *H. destructor*, (2) whose emergence holes in dry posts under a house sometimes look like a scattered charge of No. 10 shot. Fortunately, attacks by this beetle are generally restricted to sapwood and do not materially reduce the compression strength of the wood. However, in a timber or plank consisting mostly of sapwood, the damage may be very extensive resembling that of true powder-post (*Lyctus*) beetles. A small ant-like, wingless hymenopteran sometimes parasitizes the larvae of this beetle in their tunnels, but it is never sufficiently abundant to wipe out the pest.

European furniture beetle

Increasingly frequent infestations of homes are occurring in Vancouver, of the European furniture beetle, *Anobium punctatum* DeGeer, erroneously called the death-watch beetle. These arise from heirloom furniture imported from Europe or from antique furniture purchased locally. From these sources, the beetles may spread throughout the house; but they attack chiefly Douglas fir sapwood occurring in the basement. From furniture in the upper part of a house, beetles may infest oak or maple floors and then spread into the basement. They perforate hardwood very thoroughly and also attack curved surfaces of log furniture and walls.

Opsimus quadrilineatus Mann.

A very unusual record is that of this longicorn, which was extremely plentiful in the enormous log house mentioned earlier. In one measured linear foot of a post of 7 inches diameter, occurred 91 emergence holes. Two varnished 30-foot key posts supporting the roof, were similarly perforated. Each mature larva throws a cascade of sawdust out of the oval hole it cuts to the surface and then retires backwards to pupate inside the tunnel.

This is one insect that definitely oviposits in its old tunnels and in those of *B. aurulenta* into which it readily retreats when alarmed. I have

studied the newly-hatched *Opsimus* larvae burrowing into the walls of old buprestid tunnels where the eggs were laid, throwing out behind them cascades of minute particles of sawdust and frass. Adults of this brown, 18-22mm. beetle are very active, flying freely around a house by day and by lamp-light; they are also active in dim light as in a windowless basement.

This insect infests chiefly the curved surfaces of varnished and unvarnished vertical posts and horizontal logs. However, I have a record of one larva each, attacking two 6 x 6-inch beams in one house, and another record of a heavy infestation in a short length of 2 x 3-inch wood which must have been infested when the wood was freshly cut, before it was painted.

Log houses in heavily wooded areas and the shady side of other log houses are more subject to attack than those out in the open.

Powder post beetle

Lyctus brunneus (Steph.) occurs sporadically in Vancouver, emerging from oak floors, usually within one year of the floors being laid. They do not reinfest the house. They occur mostly in ¾-inch grooved and tongued mill-end strips imported from some five southern states. All oak flooring is required to be kiln-dried before being exported, but eggs are apparently deposited in the strips after being dried and while piled in yards, before it can be shipped.

The firm importing most of this oak flooring brings in several million feet annually and considering the huge amount imported, infestations are relatively uncommon. Retail flooring firms replace infested pieces without dispute.

Infestations of *Lyctus planicollis* Lec. occasionally occur in imported furniture and another species not infrequently destroys bamboo articles shipped from China or Japan such as strip screens, picnic baskets and garden posts. Usually this occurs within one year of the goods being brought in.

Garden ant

The last insect of any consequence that infests woodwork in local homes, is the common garden ant *Lasius niger* s. sp. which often becomes established in timbers that have been wet for a long time and are rotten at the centre. Sills lying on concrete walls and sills below windows that are dampened by contact with outside earth; studding inside a wall that is drenched from a leaking roof and soggy timbers under concrete steps — all these may become infested and completely tunnelled by colonies of this ant. Every summer large flights of reproductives of both sexes, the brown and yellow females ten times the bulk of the black and brown males, pour out into the house causing great alarm. Sometimes flights develop in nests in the ground adjacent to walls and the winged forms move into the wall under the siding or stucco and emerge into the rooms from behind the quarter-round or baseboard, giving the impression of having developed in the wall itself. Removing the cause of the dampness and replacing the sodden wood, is the answer to this trouble.

Wharf borer

Nacerda melanura (Linn.), the wharf borer (3), seems to be spreading widely in Vancouver. It came to my notice first in 1945 in piling at a sugar refinery. In 1952 one specimen was sent me from a greenhouse on the property of this same refinery. In 1957 a very large number of beetles emerged from under the flooring of the branch library at Kitsilano where sodden timbers, rotting in a dead-air space, were perforated by larvae and beetles. During April-May, 1958, an immense number of beetles infested a black-topped parking lot in the heart of downtown Vancouver. The owners said that this was the third year that the beetles had appeared but never in such numbers and they were causing

great alarm. Emergence was from cracks in the asphalt around a small concrete office. The manager mentioned that timbers from large wooden buildings formerly on the site, were buried under the present office so the flood of beetles must have come from this rotting wood. Like the swarms of *Lasius niger*, the presence of these insects is an effect, the result of sodden wood and not the cause of wood decay.

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DISTRIBUTION OF STORED FOOD INSECTS IN BRITISH COLUMBIA[1]

PETER ZUK[2]

This is a report of a continuing survey of grain elevators, cereal warehouses, and flour mills in British Columbia for the seven years 1952 to 1958, to determine the distribution and relative importance of established stored food insects.

A few reviews have been published on these pests in British Columbia. Follwell reported on the Ptinidae in cereal warehouses (1952) and issued a circular on stored product insects and their control (1953). King (1953) assembled some information on these pests and Gray (1953-56) listed the ones most commonly found. Spencer (1942) recorded some of the common forms occurring in dwellings.

The present survey consisted of visits to establishments in the large centres in the province, from Vancouver to Cranbrook in the south and to Prince George in the north. On Vancouver Island warehouses were inspected from Victoria to Courtenay and Port Alberni. In the interior and on Vancouver Island inspections were made during July or August only, but on the lower mainland they were made throughout the year.

An inspection consisted of a check of the premises for crawling and flying insects and an examination of the stored food in sacks and in bulk. Some specimens were obtained by screening samples. The insects taken were often brought to the laboratory to be reared and questionable specimens were submitted to the Systematics Unit, Ottawa, for identification.

A total of 584 visits was made to establishments during the seven years, in which 35 species of insects were recorded:

Year	Firms visited	Species
1952	101	21
1953	108	25
1954	80	16
1955	76	17
1956	40	14
1957	97	20
1958	82	19

In many cases the same species of insects showed up year after year in the same premises. Table I shows that the most widespread insects were: the Australian spider beetle, *Ptinus ocellus* Brown (*P. tectus*); yellow mealworm, *Tenebrio molitor* L.; black carpet beetle, *Attagenus piceus* (Oliv.); and the granary weevil, *Sitophilus granarius* (L.). Other insects of prime actual or potential importance under all B.C. conditions are: cadelle, white-marked spider beetle, saw-toothed

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grain beetle, confused flour beetle, Mediterranean flour moth, Indian meal moth, meal moth, brown house moth, white-shouldered house moth. These insects are not necessarily widespread in the province, but when found are usually in large numbers and are capable of rapid build-up. Frequent treatment is required to keep the numbers down.

Pests of lesser importance in the province, with the possibility of serious outbreaks, are: drug store beetle, rusty grain beetle, varied carpet beetle, larder beetle, hide beetle, black flour beetle, broad-horned flour beetle, tobacco moth, *Aphomia gularis* (Zell.), booklouse, grain psocid, grain mites.

A third group follows, of local importance by reason of comparatively low reproductive rate, unsuitable climate or restricted food range: rice weevil, carpet beetle, *Trogoderma simplex* Jayne, fungus beetle, bean weevil, *Pseudeurostus hilleri* (Reit.), golden spider beetle, hairy spider beetle, globular spider beetle, Angoumois grain moth, European grain moth.

The numerous occurrences recorded at Vancouver and Victoria reflect the size and diversity of the food industry in these cities. Most of the species listed are cosmopolitan, but some (*e.g., P. ocellus*), though widely distributed, are confined to the temperate regions of the world. The table gives no indication of the intensity of the infestations, since considerations of time and travel did not permit quantitative assessments. These are

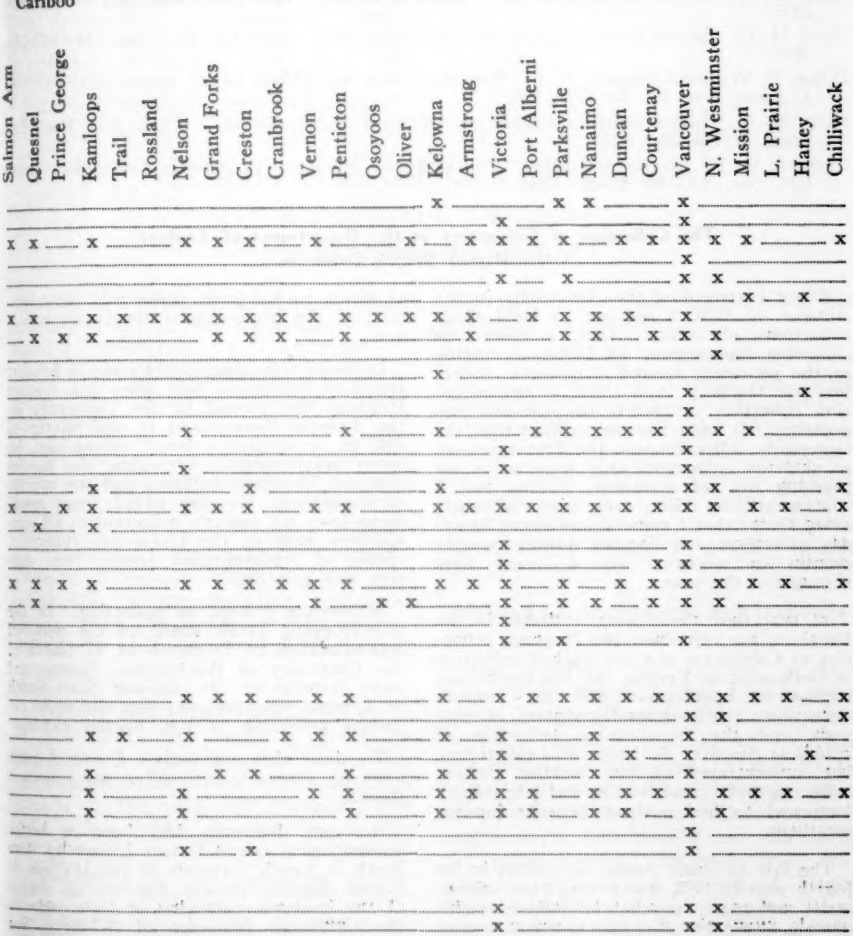
TABLE I.—Distribution of stored food insects by towns and cities in British Columbia, from 1952 to 1958

			Salmon Arm	Quesnel
COLEOPTERA				
Anobiidae	*Stegobium paniceum* (L.)	drug-store beetle		
Cucujidae	*Cryptolestes ferrugineus* (Steph.)	rusty grain beetle		
Curculionidae	*Sitophilus granarius* (L)	granary weevil	x	x
	S. oryza (L.)	rice weevil		
Dermestidae	*Anthrenus verbasci* (L.)	varied carpet beetle		
	A. scrophulariae (L.)	carpet beetle		
	Attagenus piceus (Oliv.)	black carpet beetle	x	x
	Dermestes lardarius L.	larder beetle		x
	D. maculatus Deg.	hide beetle		
	Trogoderma simplex Jayne			
Mycetophagidae	*Mycetophagus quadriguttatus* Mull.	fungus beetle		
Mylabridae	*Acanthoscelides obtectus* (Say)	bean weevil		
Ostomatidae	*Tenebroides mauritanicus* (L.)	cadelle		
Ptinidae	*Pseudeurostus hilleri* (Reit.)			
	Niptus hololeucus (Fald.)	golden spider beetle		
	Ptinus fur L.	white-marked spider beetle		
	P. ocellus Brown	Australian spider beetle	x	
	P. villiger (Reit.)	hairy spider beetle		x
	Trigonogenius globulus Solier	globular spider beetle		
Silvanidae	*Oryzaephilus surinamensis* (L.)	saw-toothed grain beetle		
Tenebrionidae	*Tenebrio molitor* L.	yellow mealworm	x	x
	Tribolium confusum Duv.	confused flour beetle		x
	T. destructor Uytt.	black flour beetle		
	Gnathocerus cornutus (F.)	broad-horned flour beetle		
LEPIDOPTERA				
Phycitidae	*Anagasta kuehniella* (Zell.)	Mediterranean flour moth		
	Ephestia elutella (Hbn.)	tobacco moth		
	Plodia interpunctella (Hbn.)	Indian meal moth		
Pyralididae	*Aphomia gularis* (Zell.)			
	Pyralis farinalis (L.)	meal moth		
Oecophoridae	*Hofmannophila pseudospretella* (Staint.)	brown house moth		
	Endrosis sarcitrella (L.)	white-shouldered house moth		
Gelechiidae	*Sitotroga cerealella* (Oliv.)	Angoumois grain moth		
Tineidae	*Nemapogon granella* (L.)	European grain moth		
PSOCOPTERA				
Liposcelidae	*Liposcelis divinatorius* (Mull.)	booklouse		
Atropidae	*Lipinotus patruelis* Pearman	grain psocid		

not necessarily the only occurrences but it is probable that there are no others, for they would otherwise have been detected either in the inspections or by being brought to the attention of the laboratory by management of the firms.

The volume of international commercial traffic into west coast ports will undoubtedly result in other pests becoming established in the province. An example of a recent successful introduction is the Pyralid, *Aphomia gularis* (Zell.), which was recorded for the first time in Western Canada in 1952 in a bakery supply house in Vancouver. It has since spread by commerce to flour and feed warehouses on Vancouver Island. The merchant grain beetle, *Oryzaephilus mercator* (Fauv.), is very frequently intercepted by Plant Inspection Officers in imported cargoes, but it is not yet established.

Inquiry is sometimes made regarding the khapra beetle, *Trogoderma granarium* Everts. This pest of major economic importance is now well



established in the south-western U.S. It has not yet appeared in B.C. nor is it likely to become established because the climate is unsuitable (Howe and Lindgren 1957).

Acarina are of economic importance at the coast, especially *Acarus siro* L. However, mites are not included in this list since they are seldom important away from the coast, and because they cannot be recognized on sight.

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The Collection of Coleoptera in the Department of Zoology, University of British Columbia

When I arrived at this University in the Autumn of 1924, I set out to build three collections of insects: first, a systematic collection representing all Orders occurring in the province; second, a synoptic collection for teaching; and third, a demonstration collection of insects of economic importance. It soon became evident that the systematic collection was the first essential, so skeleton collections only were made for teaching and of economic insects, and I concentrated on taking every insect of nearly every Order that I came across every Saturday afternoon and Sunday during summer months or whenever else I found them throughout the year.

At that time there were available in the Province, for reference, the Hopping collection of Coleoptera and the Buckell collection of Orthoptera at Vernon, the Blackmore collection of Lepidoptera and the Downes collection of Hemiptera-Homoptera in Victoria and the Glendenning collection of aphids at Agassiz. So I took no Lepidoptera, but concentrated on the smaller Orders, collecting only those beetles and bugs that I happened to find without actually hunting for them.

The late Kenneth Auden, a student in his fourth year in 1924, was a very keen coleopterist and gave me what he called "trash", namely duplicates of a few common species of which he had large series and these constituted the beginning of the beetle collection.

In time I had accumulated some 26 Schmitt boxes of beetles so that when Mr. George Hopping was loaned to the University by the Federal Government in the winter of 1945-46 to lecture in forest entomology, he spent seven months arranging the beetles into two 18-drawer cabinets and one cabinet of duplicates. He also added some specimens from his father's collection to fill conspicuous gaps in the University collection, chiefly of representative species from outside this province.

Meanwhile I kept on collecting. In the post-Hopping years, much of the material was identified by Professor M. H. Hatch of the University of Washington, Seattle, and more latterly by Mr. Gordon Stace-Smith of Creston who probably has the most extensive collection of B.C. beetles extant.

To these three specialists I owe a great debt of gratitude and offer my sincerest thanks.

No one, however, has been a better entomological friend to our University than Hugh B. Leech, formerly of the Division of Forest Insects, Vernon, but now in charge of the immense collection of Coleoptera at the California Academy of Sciences, San

Francisco. Mr. Leech not only named any beetles I sent him, but ever since his student days at this University, has given me insects of many Orders for our collections. In the one year that he was a student here in 1956-57, Hugh's son Robin carried on in his father's beetling footsteps. We owe a great deal to this father and son team and acknowledge it with pleasure and gratitude.

Many students also, over the years, have given us specimens we lacked or those of which we had very small series.

On 11 March, 1952 the beetle collection was counted by five senior students in Entomology and again on 18 October, 1957 by Michael J. Daniels, a graduate student in Zoology: the totals are shown below.

	March 1952	October 1957
Number of families		80
Total specimens	24484	30616
Duplicates only	10084	10231
No. of B. C. species	1138	1538
Total species	1864*	2211

* Errors, omissions and additions excepted.

The gain in five and one half years is exactly 400 species and 6132 specimens, a pleasing total. There is still a long way to go to catch up to Mr. Gordon Stace-Smith who has over 2400 B.C. species and an unknown number of specimens. On the other hand, considering that there was not ONE SINGLE beetle here when I arrived, these totals are gratifying especially when one considers the other orders I have assembled, *e.g.*, some 6000 specimens each of Hymenoptera and Hemiptera, about 4000 Orthoptera, 12000 Diptera and minor Orders in proportion.

These figures emphasize what I have pointed out repeatedly, namely, that British Columbia is an entomologist's paradise.

—G. J. Spencer, University of British Columbia, Vancouver.

TRITHION AS AN ORCHARD INSECTICIDE[1]

D. P. PIELOU and R. S. DOWNING[2]

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Trithion[3], formerly known as Compound R-1303, is the brand name of a material containing *O*, *O*-diethyl *S*-(*p*-chlorophenylthiomethyl) phosphorodithioate (Stauffer Chemical Company, 1956).

This paper is a summary of the main, or typical, findings of experiments that we carried out with Trithion in the Okanagan Valley of British Columbia from 1955 to 1957. Though otherwise excellent, this material has a shortcoming indicated herein, that precludes its recommendation for use in British Columbia orchards.

Trithion has been available as a 25 per cent (by weight) wettable powder and as a "flowable" material, an aqueous emulsion containing 4 pounds of the technical chemical per U.S. gallon. We do not know the nature of the so-called inert materials in either formulation.

The compound interested us as a general insecticide comparable with Diazinon [*O*, *O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate] in having "wide-spectrum" effectiveness against several groups of orchard insects and mites (Pielou and Proverbs, 1958) and was compared directly with Diazinon in many of our orchard trials.

Method of Application and Deposits on Leaves

The material was applied in two ways. First, large blocks of trees were sprayed with a standard air-blast concentrate machine moving at one mile per hour and applying 75 gallons of liquid per acre. This amount, in a mature orchard, gives full foliar coverage with practically no leaf-drip. With this method the insecticide was usually applied at 8 pounds of 25 per cent wettable powder per acre (concentration of active ingredient in

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3. Stauffer Chemical Company, California.

water in the sprayer tank, approximately 0.27 per cent by weight). Secondly, the insecticide was applied as a high-volume, dilute spray with a gun machine, or, to small trees, with a hand-operated barrel sprayer. In either case spray was applied until all leaves were dripping. Normal dilutions were one or two pounds of 25 per cent wettable powder or equivalent emulsion in 100 gallons of water (concentration of active ingredient in water approximately 0.025 and 0.05 per cent by weight respectively).

Chemical analysis of leaves immediately after the spray had dried showed that concentrate application at the standard 8-pound rate results in deposits averaging 3.05 micrograms Trithion per square centimetre. Dilute application at the one- and two-pound rates gave deposits averaging 2.33 and 5.70 micrograms per square centimetre respectively (Pielou and K. Williams, unpublished observations).

Control of the Codling Moth

The codling moth, *Carpocapsa pomonella* (L.), is the most serious apple pest in British Columbia. For a number of years it has been assumed that control of this species could only be attained if there is a persistent deposit, above a certain minimum value, of a suitable insecticide on leaves and apples during the period of emergence and oviposition of the first brood (approximately from the end of May to the end of June) and, sometimes, of the second brood (approximately the first two weeks in August). DDT has been a standard material (Marshall, 1953) for such "cover" sprays in British Columbia for the last twelve years and is used as a reference material in testing new insecticides. Though DDT is satisfactory the possibility of the appearance of DDT-resistant strains of the codling moth in British Columbia warrants search for new insecticides.

In 1956, plots in an orchard of Red Delicious apples were treated with four cover sprays on May 25, June 11 and 27, and July 30. Application was made with an efficient air-blast concentrate sprayer travelling at one mile per hour. The materials compared were 50 per cent DDT wettable powder at 6 pounds per acre (*i.e.* 3 pounds active material) and 25 per cent Trithion wettable powder at 9 pounds per acre (*i.e.* 2¼ pounds active material). No sign of spray injury was seen though the residue of Trithion had a rather objectionable, spotty appearance. At harvest, 500 apples were picked from each of five trees for each treatment. The percentages of wormy fruit for the treatments were: DDT, 10.7; Trithion, 9.0. The corresponding percentages for "stings" (unsuccessful larval attacks) were 3.3 and 2.2. The difference is not statistically significant in either case.

In 1957 the experiment was repeated on Red Delicious, Golden Delicious and McIntosh apples. The layout of the orchards did not permit randomization of varieties, so comparisons are only possible between the two materials within varieties. On Red Delicious at harvest the percentages of wormy fruit for the treatments were: DDT, 6.6; Trithion, 10.8. On Golden Delicious: DDT, 12.5; Trithion, 17.5. On McIntosh: DDT, 8.4; Trithion, 7.7. These would be high figures in commercial control but we deliberately choose heavily infested orchards, so initial population was high. None of the differences are statistically significant. Trithion appears, therefore, as equal to DDT for control of the codling moth.

Considerable foliar damage occurred with Trithion in 1957; this is referred to later.

Control of the Eye-Spotted Bud Moth

The larva of the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), does not damage the fruit in the serious way that the codling moth larva does, but the superficial injury is a blemish, which, with the present premium on surface finish, downgrades the fruit. In the 1956 trials against the codling moth, the eye-spotted bud moth was also common in the experimental plots.

Bud moth injury affected only 1.0 per cent of the fruit in the Trithion plots but was 10.2 per cent on the DDT plots. In another experiment an infestation of bud moth on cherry was totally destroyed with Trithion.

Control of the Apple Aphid

We have compared Trithion with other aphicides for the three years that trials have been in progress. Malathion [*S*-(1, 2-dicarbethoxyethyl)-*O*, *O*-dimethyl phosphorothithioate] has been used as the reference material because it is the recommended aphicide for British Columbia. The apple aphid, *Aphis pomi* DeG., has become, after the codling moth, the most serious pest of apple in British Columbia.

The state of affairs, and the effectiveness of Trithion, may be illustrated by the following examples:

1. A good commercial orchard of McIntosh and Red Delicious apples under sprinkler irrigation and with permanent grass cover crop was moderately infested with aphids. The trees in this orchard were up to 18 feet high, well pruned, at the peak of production, and not overfertilized. Separate plots of 17 to 23 trees each were sprayed in late July with Trithion and Malathion emulsions. Application was at the rate of 4 pounds of active ingredient per acre, with an air-blast concentrate sprayer applying 75 gallons of liquid per acre. On three occasions after application ten terminal twigs were cut at random from each of ten trees for each treatment. As apple aphids tend to congregate on the uppermost leaves of a twig, the five terminal leaves on each twig were closely examined for living aphids. In all, 500 leaves per treatment were examined on each occasion. Results are shown in Table I where the figures indicate total aphids per 500 leaves. It will be seen from the table that re-infestation was almost complete within three weeks. Trithion and malathion were approximately equally effective.

TABLE I

Days after application	4	10	20
Trithion plots	3	21	161
Malathion plots	6	30	198
Untreated plots	320	282	265

2. When five-year-old Red Delicious trees, growing very vigorously, were sprayed with the two materials at the same rates, somewhat different results were obtained. These trees had, initially, a much heavier infestation (over 100 aphids on some leaves) than those in the preceding example. Three days after application almost complete kill was noted on exposed, uncurled leaves with both materials. When the young leaves of the growing points of twigs were unfolded, however, eight survivors were found per terminal with the malathion treatment and three for the Trithion treatment. In view of the many small branches that were involved, this meant a considerable total of living aphids on each tree. Considering the great reproductive potential of the apple aphid these constituted a ready source of infestation. The difference with the two materials is just statistically significant.

3. We have carried out extensive experiments on dwarf apple trees (growing on Malling IX dwarfing rootstock). On these trees insecticide was applied as a conventional, dilute spray at 0.5 pounds of active ingredient per 100 gallons. These experiments, as a whole, showed that Trithion was significantly better against the apple aphid than malathion: On these well-growing, much branched and well-fertilized small trees, survival of aphids on uncurled leaves after treatment with malathion was approximately five per cent on the average. On such leaves complete mortality was nearly always achieved with Trithion. However, when the tightly curled

young leaves at the tips of the terminals were examined, survivors were found with both materials. The percentage of survivors varied in different experiments but there were significantly fewer with Trithion in nearly every case.

At this point it is noteworthy that other work at the Summerland laboratory (Pielou and K. Williams, unpublished) showed that although Trithion has a persistent residue, chemically detectable after three weeks, the residue is ineffective in preventing reinfestation by the apple aphid. This is because the fall-off in deposit, to a level insufficient to affect aphids, is very rapid in the first three days. However, the small residual deposit appears to be effective against the European red mite, *Metatetranychus ulmi* (Koch), about two weeks after application (Downing, 1958).

Only a few years ago, fruit growers applied special spray treatment to control the apple aphid; at most, a single application per season of one of the older aphicides such as nicotine kept this aphid at a subeconomic level. However, in recent years infestations have increased, and they have persisted for a longer part of the season. Several applications of aphicides have often been necessary and there have been many complaints from growers that malathion was ineffective and some contention that the insect had developed strains resistant to this material. However, we have no evidence for development of strains resistant to malathion and our experience suggests an alternative hypothesis. As indicated above, where mature, reasonably fertilized trees with not much succulent new growth, have been sprayed with malathion we have achieved almost perfect control, as we have done also with newer organic phosphate materials. Admittedly, reinfestation by winged aphids from other sources has often taken place within two to four weeks. However, when malathion has been applied to young, vigorously growing trees with plently of succulent growth arising from plentiful watering and nitrogenous fertilizer, we have not achieved satisfactory control. Such trees are apt to support a very high population of the apple aphid; these aphids have a strong preference for the terminal growing tips of the twigs. There, large numbers of aphids cause leaf curling and consequently are well protected; although malathion destroys nearly all aphids on exposed leaves there are always a considerable number of survivors in the curled terminal leaves. Better results were achieved with Trithion but perfect control was rare.

Apart from the mechanical protection afforded by curled leaves, together with the very high populations that offer a greater chance for some survival, the experiments described above suggest that aphids on such young, vigorous trees are more difficult to kill than those on mature trees. Aphids surviving on such trees provide a source of reinfestation for all trees.

Changes in cultural practices in the last decade, rather than destruction of predators by DDT, seem to have brought about the overall increase in apple aphid populations. Use of high-nitrogen fertilizers, such as ammonium nitrate, has increased without any reduction in the total quantity of fertilizer applied per acre. And there has been a change from furrow irrigation to sprinkler irrigation with consequent greater use of water. Along with the change to sprinkler irrigation clean cultivation has been abandoned in favour of permanent or semi-permanent cover crops. The vigorous, succulent growth induced in trees, especially young trees, and the general increase in moisture and humidity appear to have created ideal conditions for what can only be described as the culture of aphids in orchards. This is the most probable explanation of present high aphid populations, of the ready reinfestation after control and of the impossibility of achieving seasonal control with a single application of any of the current insecticides.

Control of Other Aphids

Trithion at two pounds of 25 per cent wettable powder per 100 gallons applied with a high-volume sprayer gave almost perfect control of the thistle aphid, *Anuraphis cardui* (L.), on prunes and of the mealy plum aphid, *Hyalopterus pruni* (Geof.) (=*H. arundinis* (F.)), on prunes and apricots. After a single application in the summer it was difficult to find any living aphids. Reinfestation with either of these species is generally not a problem if the entire orchard is sprayed. The mealy plum aphid on old apricot trees over 20 feet high was also effectively controlled by a single application of Trithion, at eight pounds of 25 per cent wettable powder per acre, with a concentrate sprayer.

Because of the lack of infestations only a few tests were carried out on the black cherry aphid, *Myzus cerasi* (F.) and these were on very small trees. At two pounds of 25 per cent wettable powder per 100 gallons 100 per cent mortality was achieved. A difficulty in controlling the black cherry aphid is that cherry foliage is particularly susceptible to injury from malathion and there are objections to other common aphicides (Pielou and Proverbs, 1958). Trithion caused some foliar damage (vide infra) but less than malathion. However, Diazinon, the material now recommended, is practically harmless to cherry foliage (Pielou and Proverbs, 1958).

We have not done any work with the green peach aphid, *Myzus persicae* (Sulz.), an occasionally troublesome pest of peaches. This aphid has been present only at a low level in the Okanagan Valley in the last three years. However, experiments elsewhere suggest that Trithion gives only indifferent control of this aphid.

Control of Lecanium Scales

Scale insects of the genus *lecanium* have become a serious problem on peaches and apricots in the Okanagan Valley in the last few years. Trithion applied in the dormant stage at 2.4 pounds of 25 per cent wettable powder, as a dilute spray from a hand-gun machine controlled these insects. But application four weeks later, when the buds were showing pink, was less effective. Malathion application at the latter date and rate was decidedly inferior to Trithion. However, Trithion, at this stage of plant development, was inferior to Sevin [N-methyl-1-naphthyl carbamate; Union Carbide Chemical Company, White Plains, N.Y.] which gave excellent results. In July the average numbers of surviving scales per 50 leaves were: Sevin, 64; Trithion, 228; malathion, 349; untreated, 1580.

Control of the European Red Mite

Some data have been recorded on the effect of Trithion on the European red mite, *Metatetranychus ulmi* (Koch), in comparison with other materials (Downing, 1958). Trithion, when applied at the pink-bud stage, gave good control of the mite on apple. After application by air-blast concentrate sprayer at the rather high rate of 16 pounds of 25 per cent wettable powder per acre on Red Delicious trees in early May, the density of mites was 0.10 per leaf in early June and 0.81 per leaf in early August. Comparable figures on plots that received no treatment were 0.27 and 19.8 per leaf.

As a summer spray, Trithion was also effective. Trithion was applied to Winesap apples in mid-July at the rate just mentioned. At the end of July the average number of mites was 1.74 per leaf; by mid-August, 0.46 per leaf. The comparable figure on untreated trees was 21.8 per leaf by the end of July, the population being so high that these control trees had to be sprayed to satisfy the grower.

Control of Brown Mite

Trithion, applied as a dilute spray in summer at one pound of 25 per cent wettable powder per 100 gallons, reduced populations of the brown mite, *Bryobia arborea* M. & A. from 21.6 per leaf of 8.6 in ten days and to zero in six weeks. The comparable figures

on untreated trees were 22.0, 5.6 and 13.4. Trithion was also significantly superior to the specific miticide, sulphenone [*p*-chlorophenyl phenyl sulphone; Stauffer Chemical Company, Mountain View, California] recommended for the brown mite in British Columbia.

Control of the McDaniel Spider Mite

Application of Trithion by air-blast concentrate sprayer in summer at the somewhat high rate of 12 pounds of 25 per cent wettable powder per acre reduced the number of the McDaniel spider mite, *Tetranychus mcdanieli* McG., to an average of 1.6 per leaf in eight days and to 1.2 per leaf in 21 days. With application at eight pounds per acre the figures were 4.6 and 2.7. The comparable figures for untreated trees were 24.2 and 25.4. Control of the McDaniel mite with Trithion was as good as with the miticides now recommended.

Control of the Apple Rust Mite

The apple rust mite, *Vasates schlechtendali* (Nal.) has been controlled with Trithion. On Italian prunes, application of a dilute spray with a gun-type machine reduced the number of mites from 203 to less than one per leaf in 26 days. As the rust mite is much smaller than those previously mentioned, this reduction in numbers is regarded as evidence of adequate control. On untreated trees in this experiment there was some reduction from natural causes, but there were still 64 rust mites per leaf after 26 days.

Trithion was ineffective against another common eriophyid, the pear leaf blister mite, *Eriophyes pyri* (Pgst.).

Phytotoxicity

Although in 1955 and 1956 Trithion had produced no signs of leaf or fruit damage when applied either as dilute or concentrate sprays, in 1957 damage from this material was evident in several orchards. On Golden Delicious apple the damage was particularly bad. Two weeks after the second cover spray, yellowing and necrosis of many leaves were apparent and defoliation was beginning; another two weeks later, defoliation was extensive. In some plots, further application of Trithion had to be discontinued for fear of total defoliation. At harvest time, the apples showed some russetting and were smaller than those from trees that had been sprayed with DDT. On Red Delicious, there was no serious defoliation but the leaves showed numerous purple spots that later became necrotic. Up to 50 per cent of the leaf area was affected in this way. McIntosh foliage showed least injury although some leaf spotting was eviden in the lower branches.

Some yellowing of leaves and slight defoliation were evident on apricot and cherry trees to which dilute sprays of Trithion had been applied. Severe defoliation of cherry occurred after application of concentrate spray as a drench. Trithion also caused some yellowing of the foliage of strawberries, ornamentals, and certain vegetables.

Both wettable powder and emulsion formulations of Trithion caused injury in 1957. It was first thought that the damage might have been due to a change in formulation. Tests of phytotoxicity therefore were carried out with some of the material supplied in 1956. Again, serious leaf spotting and defoliation were apparent, particularly on the variety Golden Delicious. It seems probable, therefore, that the technical material itself is responsible for the damage and that growing conditions (1957 was a late season with cool summer) were particularly favourable for damage. Alternately, perhaps, climate conditions favoured weathering of Trithion to some particularly phytotoxic breakdown product in 1957. In any case, in view of the importance of the varieties, Red Delicious and McIntosh, and the rapid increase in plantings of Golden Delicious, we considered that Trithion, in spite of its great insecticidal potency and the fact that it caused damage only in one year out of three, could not be recommended to the

growers. Moreover, there are reports of damage in Trithion trials from Washington State (Anthon, 1958) and from Australia (G. Miller, Tasmania Dept. of Agriculture, private communication).

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ERADICATION PROCEDURES FOR ORIENTAL FRUIT MOTH IN THE OKANAGAN VALLEY OF BRITISH COLUMBIA

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In 1957 plans were outlined for the eradication of a potential infestation of oriental fruit moth in the Southern Okanagan Valley (1). It is now intended to report on what was done and the results as noted to date.

In the fall of 1956 the ripening rooms of the two canneries involved were fumigated with methyl bromide. This served as an immediate check on the most probable locations of infestation as the fruit had been placed in these rooms on arrival and before going into cold storage until processed.

Extensive organization by federal and provincial authorities resulted in an early spring and summer program of insect elimination. This included cannery fumigation, removal of trees and fumigation of the orchard land where possible infested fruit waste had been scattered, fumigation of other waste dump areas, spraying of orchards adjacent to canneries and compensation for any losses, and trapping for possible recovery of adult oriental fruit moths throughout the Southern Okanagan Valley.

Early in the year fumigation matters were attended to and a deadline date of April 6, 1957, was set. After contracting for the fumigation of the canneries and certain land areas, it was necessary to assemble a great deal of material, including electric gas analyzers, polyethylene tubing, thermometers, leak detectors, test insects, cages, extension cords, etc. A mobile laboratory was obtained to house the gas analysis equipment. The fumigators, Columbia Pest Control, Ontario, California, supplied their own tarpaulins to cover the areas and, on March 13th, started to cover the cannery of York Farms, Osoyoos. This was completed in one day. The area fumigated was 333,015 cubic feet. In this same vicinity it was required to fumigate a junk pile of 11,000 cubic feet, settling pits of 13,000 cubic feet, and a fruit refuse dump area of 4,500 cubic feet.

On March 18th the operators moved to Barkwill Cannery at West Summerland. The area involved in the cannery fumigation was 298,000 cubic feet, an adjacent hillside 10,000 cubic feet, the orchard area 423,600 cubic feet, with a re-fumigation of 16,800

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cubic feet. A grand total of 1,109,915 cubic feet was fumigated. In all cases the initial dosage was at the rate of 5 lbs. methyl bromide per 1,000 cubic feet.

Prior to the fumigation of the orchard land the trees had been removed to one foot stumps, the trees being burned. In order to support the tarpaulins for the land fumigation, apple boxes were placed between the tree stumps to allow better circulation of the gas. Over 4,000 boxes were used and these had to be moved as each section was treated. The entire orchard was treated in 27 sections, ranging in size from 4,000 square feet to 38,000 square feet, with the average approximately 15,000 square feet. The initial dosage in all cases was at the rate of 5 lbs. methyl bromide per 1,000 cubic feet. Due to the tremendous soil sorption, especially in gravelly sections, the average amount of methyl bromide required was approximately 23 lbs. per 1,000 cubic feet.

The steep hillside adjacent to the cannery posed another problem in supporting the tarpaulins. This was solved by constructing a framework of 2 x 4's attached to stakes driven into the ground. The desired concentration of gas was maintained with 13 lbs. of fumigant per 1,000 cubic feet, with fan circulation.

The final fumigation was completed on April 10th, which was considered satisfactory for the project.

Following fumigation all roadways, parking areas and areas immediately adjacent to both canneries were thoroughly sprayed with diesel oil plus 25% emulsifiable DDT, 4 lbs. actual per 100 gallons of oil.

A spray program had been outlined for orchards adjacent to the canneries, as a follow-up of the fumigation. In order to be able to maintain an efficient and steady spray schedule a concentrate sprayer was purchased, to be operated under the supervision of the Entomology Laboratory at Summerland. Some seven acres of orchard were sprayed in the vicinity of the Osoyoos cannery, whereas thirty odd acres were sprayed adjoining the Summerland cannery. All varieties of fruits within these acreages were sprayed, using 50 gallons of spray per acre.

The spray period for Osoyoos was April 25 to May 10/13 for apricots, and April 18 to June 21/25 for peaches and other fruits. In Summerland the spraying extended from April 29 to May 23/24 for apricots and other fruits, and from April 26 to June 26/29 for peaches. The Osoyoos apricots received three applications of DDT 50% wettable powder, 12 lbs. per acre, Colloidal Spray Modifier 1 pint per acre. Four similar applications were given to apricots in Summerland. The peach spraying started at the rate of 12 lbs. per acre but was reduced to 6 lbs. later in the season because of the residue problem. In Osoyoos 5 applications were made at the higher rate and 2 at the lower, whereas in Summerland 4 applications were made at 12 lbs. and 3 at 6 lbs. Average figures on spray residue have been provided as DDT parts per million of fruit. The legal tolerance is 7ppm. By harvest time the residue problem on peaches and apricots was of very little concern.

Special problems in arriving at grower loss and fruit compensation values were encountered. Cherry yields and grades had to be estimated on the trees as the fruit was not harvested, due to excessive spray residue. Some spray damage occurred on apricots. The amount of damage due to reduced size of fruit, excess fruit drop, and fruit burn were factors which had to be considered and reconciled so that the growers could be equitably compensated.

A trapping program was initiated to determine if oriental fruit moth had become established in the peach-growing sections of the South Okanagan Valley. Traps were set in a circumference of a mile from the fumigated canneries and in several

Fruit	Location	Last Spray	Residue on		Residue at harvest on	
Peach	Summerland	June 29	June 29	(36 ppm)	Aug. 13	(3.6 ppm)
Peach	Osoyoos	June 21	June 24	(22 ppm)	Aug. 27	(3.1 ppm)
Apricot	Summerland	May 24	June 29	(48 ppm)	July 24	(8.5 ppm)
Apricot	Osoyoos	May 10	June 24	(6.6 ppm.)		—

other strategic points throughout the Valley, from the international boundary to Summerland and into Naramata, Westbank and Kelowna. Four hundred and twenty-four traps were used. Throughout the season 9,231 trap inspections were made, using 1,360 gallons of bait which was prepared in batches of 45 gallons, using 2 gallons panomalt, 160 lbs. golden brown sugar, .5 lb. Brewer's yeast, and 42 gallons water. Two suspicious moths were found but neither proved to be oriental fruit moth.

Fruit fumigation trials were conducted at the London Laboratory, to determine the lethal dosage of the various stages of the insect, as well as the tolerance of the fruit. Modifications were made in the import regulations. Fumigation is now required only for the fruits of apricot, peach, pear, and quince.

Late season observations on the fumigated land indicated that there had been considerable killing of weed seeds, and the couch grass had been completely killed out in the entire orchard. Fruit trees which had been replanted showed very good growth, better than usual with freshly planted nursery stock.

Cost Estimates

Fumigation — including consultant fees, fumigation contract, gas, salaries, travelling expenses, extra labour	$ 43,843.00
Spraying — including sprayer, material, wages, labour	8,057.25
Trapping — including material, salaries, travelling expenses, labour	5,415.69
Provincial Government — including preliminary fumigations, orchard compensation, fruit compensation, transportation	17,333.89
	$ 74,649.83

Acknowledgments

This paper is the compilation of unpublished data supplied by Mr. L. L. Reed, Plant Protection Division, Ottawa; Dr. J. Marshall, Entomology Laboratory, Summerland, B.C.; Mr. H. A. U. Monro, Science Service Laboratory, London, Ontario; Mr. W. Molyneux, Plant Protection Division, Penticton, B.C., and Mr. R. P. Murray, Provincial Horticulturist, Victoria B.C.

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On the Reproductive Potential of the Sheep Nostril Fly *Oestrus ovis* L. (Diptera: Oestridae)

Most references state that the eggs of the sheep nostril fly hatch in the body of the mother and the fly deposits living larvae; Hearle (1) states that in one instance under observation, 60 larvae were deposited in one hour. Only one reference that I can find, (Smart, (2)) states that the fly deposits eggs.

In 1954 when working on the Lac du Bois cattle ranges some 13 miles from and 2000 feet above Kamloops, I found that newly emerged nostril flies clustered in crevices in the old log hut that was being used as a laboratory, particularly in the holes cut into the door frame to take the latches of the lock. On one morning before the sun warmed the cabin no fewer than four female flies were clustered there; they were freshly emerged and undamaged. There were no sheep on the ranges at this time so the flies may not have been chasing anything.

One of these flies was dissected to determine the egg-laying potential. The ovaries were distended with 624 eggs of uniform size each 0.4 mm. long, which readily separated out from the follicles. Abruptly smaller than this series, were strings of very tiny moniliform ova in the germaria.

It would seem that the flies lay the first quota of 624 eggs and either lay no more or remain quiescent until the second series develops. At the tips of the follicles, in the germaria, were minute embryonic eggs which probably never develop before the fly season ends.

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—G. J. Spencer, University of British Columbia.

A Food Plant of *Orthoris crotchi* Lec. (Coleoptera, cruculionidae)

On September 8, 1956, I found pupae of the weevil *Orthoris crotchi* Lec. in the seed pods of stick-leaf, *Mentzelia laevicaulis* T. and G. at Oliver, B.C. More than 100 adults were obtained in the ensuing 5 weeks from dried plants kept at room temperature. A parasite, *Bracon* possibly *nupera* Cress. was identified by Mr. C. D. F. Miller of the Systematics Unit in Ottawa.

On June 14, 1947, adult weevils were literally swarming on stick-leaf plants at Midway, B.C. In spite of its local abundance, this species is apparently rare in collections of B.C. Coleoptera.

—J. Grant, Forest Biology Laboratory, Vernon, B.C.

OBSERVATIONS ON A PINE SHOOT MOTH, *EUCOSMA SONOMANA* KFT. (LEPIDOPTERA: OLETHREUTIDAE)[1]

J. GRANT[2]

The shoot moth, *Eucosma sonomana* Kft., is one of a group of six members of this large genus which Heinrich (1923) lists as feeders on coniferous trees. In British Columbia it is known to occur across the southeastern part of the province from Elko to the Okanagan Valley and northward as far as Chase.

Ponderosa and lodgepole pines are the only hosts so far recorded in British Columbia; larvae have been reared on Englemann spruce in Montana.

The following observations were made in the summer of 1957 in the Grand Forks district, and refer only to attacks on ponderosa pine.

Life History

The pupa overwinters. It is believed that the egg is laid in early spring on the growing tips of the host tree. Young, open grown stands are most susceptible but trees up to 40 feet in height may be attacked. The larva bores into the centre of the shoot, leaving only a minute trail at first, but in the late instars, hollowing out most of the central pith. During the feeding period there are no exudations of pitch or frass; the only symptoms are a slight dwarfing of infested terminals, and a tendency to droop. When fully grown the larva bores an exit hole through the side of the shoot and drops to the ground.

Larvae from Cascade and Midway pupated in the insectary at Vernon between mid-June and early July. Pupa were kept in the insectary until the autumn, when they were placed in cold storage at 35°F. Adults began to emerge three days after the pupae were transferred to constant temperature cabinets at 70°F.

Economic Importance

Although *Eucosma sonomana* may seriously disfigure young pines by killing or distorting the new growth, it is not considered to be a pest of major importance in British Columbia. Multiple stems are the most serious deformity resulting from the death of the main leader, but as many of the infested leaders survive, the form of the tree is not always affected.

Three types of injury have been observed. Dead, slightly curved leaders

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and branch terminals are the most conspicuous evidence of infestation; because mortality occurs before growth is completed, the needles of the dead shoots are not fully expanded.

The second type of injury is caused by the breakage at the larval exit hole, of shoots that would otherwise have survived; the third is the distortion of growth of shoots surviving borer attack.

Near Cascade in a sample of 47 ponderosa pine saplings between 4 and 10 feet in height, 40 per cent were infested in 1957, 70 per cent of the infested shoots died after larval emergence, while the remainder suffered varying degrees of deformity.

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NOTES ON THE LIFE HISTORIES OF THREE SPECIES OF LEPIDOPTERA FROM SOUTHERN VANCOUVER ISLAND, BRITISH COLUMBIA

GEORGE A. HARDY

Provincial Museum

The following butterfly and two moths do not seem to have had their early stages described in any readily referable publication, if at all. Accordingly, they are submitted in the hope that they will be of interest to students of this group.

Speyeria bremnerii Edw.

A female of this large Nymphalid butterfly, caught in Saanich, was confined over a growing plant of *Viola palustris* on August 11, 1956. By August 19 it had laid between 30 and 40 ova, scattered about the stem and leaves and among the surrounding moss.

The eggs hatched August 31, and after consuming the eggshells, the larvae went into a dormant condition. They basked in the sunshine on warm days, but no further feeding or growth was noted. The 10 in. pot containing the young larvae was placed out of doors under the eave at the south side of the house, where they remained for the rest of the winter.

Ovum. Size 1.0 by .60 mm., conic-truncate, coarsely ribbed and cross-ribbed, shiny; dull cream.

Larva. 1st Instar. Length 2 mm. Head jet black, shiny. Body drab dirt colour, with a small shiny, black, cervical plate on T.1; rest of body with long, fine, un-branched, black hairs. By March 29, 1957, the whole brood seemed to have hibernated successfully and was commencing to nibble on pansy shoots. By April 9 they were 4-5 mm. long, the colour as before. The caterpillars were gregarious, bunching up in sunny patches when not feeding on the yellow pansy leaves or the violet which was then becoming available.

2nd Instar. April 16. Length 5 mm. Head shiny, black. Body black with black branched spines arising from the usual tubercles. They still massed together when not feeding.

3rd Instar. April 22. Length 8 mm. Head as before. Body as before but thin greyish subdorsals evident.

4th Instar. May 10. Length 10-12 mm. Head black, sparsely short-haired. Body blue-grey due to whitish flecks on a fuscous and ochre background; a black dorsal and a dark longitudinal line connecting the tubercles; tubercles yellowish, most noticeable on the spiracular row. The caterpillars became more independent and did not mass together so much. By May 16 the length varied from

12-18 mm. By May 18 they were feeding ravenously, so that 30 had to be transferred to another flower pot.

5th Instar. May 27th. Length 30 mm. Head dull black, pale buff mottlings on sides. Body black faintly freckled with buff. Spines shorter on T.1, bases of shafts black on first two rows, yellowish on rows 3 and 4. A double dorsal line of pale milky white with 2 black spots each side of dorsum of each segment, underside concolorous with the upper, spiracles grey ringed with black. On June 10 the largest were fully fed and 40 mm. long. Some of the smallest, however, were only half this length. The largest specimens pupated on June 11. Several more pupated on June 23 and others were preparing to do so.

Pupa. Pupation took place in a slight hollow under a root or loose tuft of grass. The cavity was usually longer than high and was thinly lined with silk. The pupa was attached to the upper side and hung horizontally due to the rigid upward curve of the last three segments. Size 18 by 6 mm. not counting the curve of the last segments; smooth and dull, due to very fine etchings. Colour piceous with ochre or clay-coloured spots and patches on the wing-cases, and a broad band of the same colour on the abdominal segments; spiracles black. Cremaster a closely packed group of short, stout, outwardly curved, hooked hairs on the truncate summit of a thick, rugose extension of the last segment.

Imago. Emerged singly over the period from July 2 to August 24, 1957.

Aemilia roseata **Wlk.**

This fine Arctiid moth has a wing expanse of 33-35 mm. The forewings are a bright brick red freely and evenly spotted with pale yellow clay colour; the hindwings are white tinged with pink. An opportunity to study the life history was afforded by the capture at light in Saanich, of a gravid female which laid more than 20 ova by July 30, 1957. The ova were scattered irregularly in small groups on the sides of the container.

Ovum. Size 1.10 by .75 mm. globular with a flattened base, smooth, shiny, with close microscopic punctuation; pale green at first gradually turning to dull grey, showing fine deep-seated spiral lines which were the hairs of the developing larva; a small black dot on the upper surface indicated the position of its head. Hatched August 9.

Larva. 1st Instar. Length 3 mm. Head smooth, shiny, pale brown. Body pale glaucous green, covered with long brown hairs. They ate about half of each shell. Fed on Douglas fir.

2nd Instar. August 19. Length 7 mm. Head more red-brown than before, covered with short, sparse hairs. Body red-brown between the tufts of reddish hairs. They ate directly into the substance of the needle from any point along its length. When not feeding, the caterpillars rested among the bud-scales at the tip of the shoot, or at full length along a needle. On August 23 a milky-white suffused line along the spiracles became evident with growth; the body very shiny between the tufts of hair, a sign of an approaching moult.

3rd Instar. August 31. Length 15 mm. Head as before. A pair of white tufts replaced the red ones on the dorsum of each segment, a pair of long, forward-pointing white hair-pencils on T.1, and a similar pair directed backwards on each of A.8. and A.9.; spiracular line irregular, white, edged with black above; spiracles grey, ringed with black, claspers and underside flesh-coloured. A dark dorsal line was evident by September 7, when the length was 20 mm.

4th Instar. September 10. Length 20 to 25 mm. Head shiny, black with labrum white. Body velvet black above with a narrow white girdle at the juncture of the segments, mostly concealed by the tufts of short dense hairs that spread out to meet one another from their individual tubercles; each tuft consisted of hairs of

two or three colours, arranged in layers white at the base, then black, and where there were three colours, yellow above and central; along the dorsum were nine pairs of tufts, one pair per segment with a similar, smaller, yellow centred pair below the spiracular line. The rest were black and white; T.1. had a pair of forward pointing white pencils of long hairs, and segments A.8. and A.9. had each a similar pair directed backwards. The admixture of the predominating white and black gave an overall ash colour to the caterpillar, the yellow points breaking up the otherwise solid appearance. Underside light fuscous, legs banded with black and white, zebra fashion, claspers pale dusky. By September 19 they were 30 mm. long. On September 27 the first caterpillar was observed spinning a cocoon among the twigs. Two larvae were still feeding on October 12 but all had spun up a day or two later. The cocoon is regularly oval, smooth and of a close, even texture, grey due to the admixture of the larval hairs.

Pupa. Size 15 by 6 mm. Dumpy in appearance, smooth, shiny with no trace of punctuation, mahogany brown. Cremaster, a group of exceedingly fine, short, slightly recurved-tipped hairs on the rounded tip of the last segment.

Pseudoglaea olivata **Harv.**

This large Phylaenid moth has a wing expanse of 40 mm. The forewings are either olive grey or have a reddish cast, the latter predominating, with darker orbicular and reniform spots outlined with lighter colour and a similar light line across the outer third. A female, taken on sugar in Saanich, September 1956, laid 30 ova between September 4 and 18, scattered over the sides of the box.

Ovum. Size .90 by .50 mm. Hemispherical, finely ribbed (about 30) and cross-ribbed, cream coloured turning pink a day later, finally becoming dark brown with an iridescent lustre by late September, remaining thus throughout the winter. Hatched March 12, 1957.

Larva. 1st Instar. Larvae emerged through holes in the side of the eggs, but did not eat the shells. Length 3.5 mm. Head large, pale brown. Body semi-translucent, drab, dusky colour with a tinge of purple; tubercles prominent, fleshy, each bearing a short black hair. After trying various plants they fed lightly on *Spiraea discolor* and *Rubus macropetalus*. By March 17 many had died, apparently of starvation. On March 29 *Rubus leucodermis* was tried. This was accepted with avidity and the larvae henceforth thrived.

2nd Instar. March 18. Length 4 to 5 mm. Head light brown. Body dull olive, a faint light dorsal, a broad white spiracular, tubercles black each bearing a short black hair, spiracles black; underside honey-colour, cervical plate brown with four white bars.

3rd Instar. March 22. Length 6 mm. Growth very slow, possibly because of the wrong food at first. Head light brown. Body fuscous grey with a faint bluish tinge, a distinct white dorsal and thinner subdorsals, spiracular broad, white, edged dorsally with black, otherwise as before; rested at full length along a stem. March 27. Length 9 to 10 mm. Head square, sutures black, a row of small black dots on each side. Body grey-green, dorsal, subdorsals and addorsals white, the last two thinner than the dorsal. Spiracular as before; underside dull greenish fuscous, legs and claspers dark. Fed on *Rubus macropetalus*.

4th Instar. March 29. Length 15 mm. Head shiny, pale, translucent green with light brown clouding on the sides. Body fuscous green, otherwise as before. Fed heavily on *Rubus leucodermis*.

5th Instar. April 5. Length 20 mm. Head and body as before; general colour fuscous with a greenish tinge, spiracles grey ringed with black. Rested along a stem partly coiled beneath a leaf. April 7. Length about

the same. Head as before. Body tinged with pale yellow or olive, dorsal edged with black which is abruptly thickened on each segment, progressively more so towards A.9. Underside whitish thickly etched and flecked with black, tubercles white with black centres, bearing a single minute hair.

6th Instar. April 11. Length 20 to 25 mm. Head as before. Body, T.1. shining brown with three white bars, general colour olive, heavily dusted with darker olive, dorsal and subdorsals black-edged, the black edges of the dorsal coalescing at juncture of segments to form a black spot. April 14. Head pale brown, strongly reticulated with fuscous. Body olive, heavily flecked with fuscous, a thin pale dorsal with black blotches on A.1. to 8; spiracular broad, white, sprinkled with greenish fuscous, spiracles white, black-ringed, underside beige, densely flecked with fuscous. T.1. pale brown with two white bars. They were full fed by April 19. Length 40 mm. Dorsal line had vanished, the dark blotches alone remaining. The larvae were very geotropic, evidently seeking a place for transformation. Two of the seven reared to maturity burrowed into the soil for pupation. By May 1 all had spun stout earthen cocoons ready for pupation.

Pupa. Size 15 by 6 mm. Smooth, shiny, entirely without punctuation; cremaster, four straight spines arranged in a transverse row, with one or two smaller ones at the base, set on the smooth rounded tip of the last segment.

Imago. Four adults emerged about July 28, 1957, the remainder having died in the pupa. The early appearance was probably due to the artificial conditions under which they were reared. The normal period of flight is in August and September.

The 27 specimens in my collection (January, 1958) consist of two colour forms, olive and red, in the proportion, approximately of 16 per cent olive to 84 per cent red, the red predominating in the sexes at about 5 to 1 in the males and 9 to 1 in the females.

A LIST OF CONE AND SEED INSECTS OF INTERIOR BRITISH COLUMBIA[1]

D. A. Ross[2]

The cone and seed insects listed by host in this article were reared from material collected in the interior of British Columbia during the period 1950 to 1955 inclusive. Most of the cone collections were taken by Forest Biology rangers, and the insects were reared by various members of the Forest Insect Survey at Vernon.

Only specimens identified at least to genus are listed here.

1. Contribution No. 471, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.
2. Forest Biology Laboratory, Vernon, B.C.

Host	Insect	Locality
Western white pine, *Pinus monticola*	*Dioryctria abietella* D. & S. *Conophthorus monticolae* Hopk. *Eucosma bobana* Kft.	Trinity Valley, Kaslo, Slocan City, Salmo, Gray Creek, Creston, Balfour.

Host	Insect	Locality
Ponderosa pine, *Pinus ponderosa*	**Dioryctria auranticella* (Grote)	Southern Interior.
	D. sp. nr. *auranticella*	Southern Interior, less common than *D. auranticella.*
	D. abietella D. & S.	Southern Interior.
	D. cambiicola (Dyar)	This twig feeder may occur occasionally in cones in the Okanagan Valley.
	**Laspeyresia miscitata* Hein.	Southern Interior.
	L. piperana (Kearf.)	Grand Forks.
	Corticaria sp.	Yellow Lake, Grand Forks, Creston.
Lodgepole pine, *Pinus contorta*	*Dioryctria abietella* D. & S.	Tagish, Y.T.; Bennett.
	Eucosma sp. prob. *bobana* Kft.	Fort Fraser.
Western larch, *Larix occidentalis*	*Polychrosis piceana* Free.	Syringa Creek.
	Henricus fuscodorsana Kft.	Sanca Creek.
	Cartodere filum Aubé	Anarchist Mountain.
Black spruce, *Picea mariana*	*Tortrix alberta* McD.	Central Interior, B.C.
	Ernobius nigrans Fall.	Germansen Landing, Valemount.
	Cartodere filum Aubé	Vanderhoof.
Engelmann and White spruce, *Picea engelmanni* and *P. glauca*	**Laspeyresia youngana* Kft.	Kluane Lake and Whitehorse, Y.T.; Interior B.C.
	**Dioryctria abietella* D. & S.	Interior B.C.
	Eupithecia albicapitata Pack.	Aleza Lake; McNaughton Lake; Woodpecker, Whitehorse, Y.T.
	Polychrosis piceana Free.	Jaffray.
	Earomyia sp.	Aleza Lake.
	Cartodere filum Aubé	Champagne, Y.T.; Fort Nelson.
Western hemlock, *Tsuga heterophylla*	*Earomyia* sp.	Aaron Hill.
Douglas fir, *Pseudotsuga menziesii*	**Dioryctria abietella* D. & S.	Southern Interior.
	D. reniculella Grt. (complex)	This foliage feeder may occur in cones occasionally in any part of the Interior.
	**Barbara colfaxiana* Kft.	Southern Interior.
	Polychrosis piceana Free.	Yellow Lake.
	Holcocera immaculella McD.	Yellow Lake, Pavilion.
	Henricus fuscodorsana Kft.	Creston.
	Corticaria sp.	Yellow Lake, Grand Forks.
	Megastigmus spermotrophus Wachtl	Salmon Valley, Lillooet, Westside.
	Earomyia sp.	Inonoaklin.
	Sciara pauciseta Felt (probably secondary)	Hedley.
Alpine fir, *Abies lasiocarpa*	*Dioryctria abietella* D. & S.	Hixon, Francois Lake.
	Laspeyresia sp.	Shelley.
	Megastigmus lasiocarpae Cros.	Natal, Hixon, Vanderhoof.
	Earomyia sp.	Prince George.

* These species are considered to be of considerable economic importance in the interior of British Columbia.

A BRIEF HISTORY OF THE LARCH SAWFLY, *PRISTIPHORA ERICHSONII* (HTG.), IN BRITISH COLUMBIA[1]

D. H. RUPPEL[2]

The larch sawfly was first noted in British Columbia at Grave Creek, tributary of the Elk River north of Fernie, in 1930, and its occurrence was reported to the Forest Insect Laboratory at Vernon in 1933 (Hopping, *et al* 1943). Since 1933 this insect has spread over the range of western larch, *Larix occidentalis* Nutt., in southeastern British Columbia. In 1952 the larch sawfly was first observed on eastern larch, *Larix laricina* (DuRoi) K. Koch, west of Fort Nelson, and in 1954 it was found on eastern larch at Cluculz Lake and other scattered points southwest of Prince George.

This insect is an important defoliator of larch east of the Rockies, but apparently none of the infestations referred to in the following notes caused any tree mortality. The larch sawfly population in British Columbia had subsided to a very low level in 1957.

History of Population Trends and Infestations[3]

1930—The larch sawfly was first noted at Grave Creek, a tributary of the Elk River, north of Fernie. It probably was present before this date.

1931-1932—Information is lacking for these years.

1933—The occurrence of the insect in British Columbia was reported to the Vernon Laboratory. The range of Larch sawfly then extended from Sand Creek to Elko and from Elko north in the Elk River Valley to Wright Creek, about 30 miles north of Fernie. Infestations were noted at Fernie and nearby Hartley and Lizard creeks.

1934—The range of the sawfly was not extended. Infestation foci were at Sand Creek, Lizard Creek, Hosmer, Corbin, McGillivray and Grave Creek.

1935—The range of the larch sawfly extended to Roosville, lower Flathead Valley, Yahk River Valley and Glinochi Creek basin immediately north of the Montana border, Gold Creek, Rosin Lake, Bull River, and north to Fairmont Hot Springs which is the northern limit of western larch in the Rocky Mountain Trench.

The insect was also found at Lumberton, where it had probably been active since 1932, and as far west as Kitchener. Infestations were confined to the Elk and Flathead River areas.

1936—Although there was a decided decrease in population levels, the range of the pest extended as far as Boswell on Kootenay Lake.

1937—Numbers of the larch sawfly decreased to a very low level, but the range extended to Slocan Lake.

1938—This year saw a build-up of the insect with infestations at St. Mary's Lake and on the headwaters of Goat River near Kitchener. No extension of range was noted.

1939—The 1938 build-up increased over much of the known range from Fernie to Slocan Lake. Infestations occurred at Kimberley, Moyie Lake, Yahk, Kitchener, Goat River, Creston, and from Boswell to Riondel.

1940—One infestation occurred at New Denver. The insect declined considerably over the remainder of the areas mentioned in 1939, but its range extended to Whatshan Lake.

1941—The larch sawfly spread to the eastern slope of the Monashee Range. The population level was a little higher in most areas but was generally low. Infestations were recorded at New Denver and Summit Lake to the north of Slocan Lake.

1942—The insect was observed for the first time in the Okanagan Valley in the Vernon area, the western limit of western larch. Infestations were noted at Gray Creek, the Kootenay River Valley west of Nelson, Slocan Valley, and from Nakusp to Needles at the Arrow lakes. Defoliation was negligible from Creston eastward.

1943—The only stands of western larch not known to have been infested by the larch sawfly were at Shuswap Lake and in a small area east of Penticton. Heavy defoliation occurred between Nakusp and Edgewood, also at Elko and Morrissey. Light to medium defoliation was noted at intervals between these general areas.

1944—Population levels were generally low with light outbreaks at Trinity Valley and Arrow Lakes Valley.

1. Contribution No. 466, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.
2. Forest Biology Laboratory, Vernon, B.C.
3. Information was gathered from the records of the Forest Biology Laboratory, Vernon, B.C.

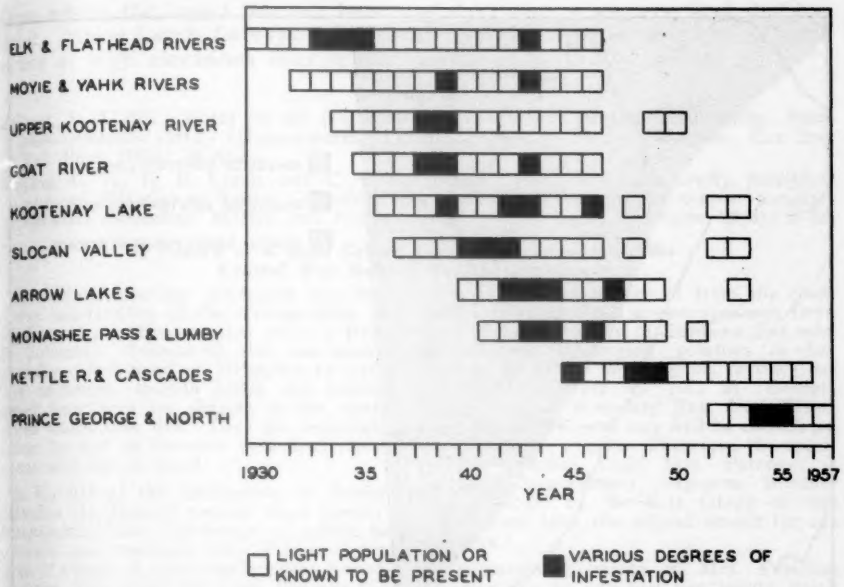

Fig. 1.—Population trends and infestations of *Pristiphora erichsonii* (Htg.), from 1930 to 1957 in British Columbia.

1945—The insect was observed in the Penticton area and Christian Valley. An infestation occurred on the Rossland-Sheep Creek Summit. From Nelson eastward the population was "very light."

1946—Lumby and Hall Creek (near Salmo) were the only localities where damage was recorded.

1947—An infestation appeared at Whatshan Lake.

1948 & '49—A light infestation occurred in the vicinity of Grand Forks, Eholt, and Phoenix. Elsewhere the insect was scarce.

1950 & '51—The larch sawfly was very scarce in Survey collections and all infestations in southeastern British Columbia had subsided.

1952—A few Survey collections from points west of Creston contained larch sawfly larvae. They were also found for the first time on eastern larch in the northern part of the province at Mill Creek west of Fort Nelson.

1953—Larch sawfly was present in small numbers at scattered points, mostly on the Kettle River drainage.

1954—The situation was unchanged in the south but an infestation developed at Cluculz Lake west of Prince George where there are scattered stands of eastern larch.

1955—The insect was very scarce on western larch in all areas. A few larvae were collected at Pantage Lake southwest of Prince George, the southern extremity of the range of eastern larch in British Columbia. A light infestation occurred at Cluculz Lake. Presence of the insect was indicated by curled leaders at Commotion Creek west of Dawson Creek.

1956—A few larvae were found in a concentrated search in the Phoenix area near Grand Forks. One colony was found at Cluculz Lake west of Prince George.

1957—The larch sawfly occurred in one collection made along the Hart Highway west of Dawson Creek, the only known record of the insect for 1957 in British Columbia.

The population trends and infestations of the larch sawfly since its appearance in British Columbia about 1930 are depicted in Figure 1. Figure 2 shows the approximate range of western and eastern larches in the province and areas where infestations of larch sawfly are known to have occurred. The Shuswap Lake area is the only part of the western larch

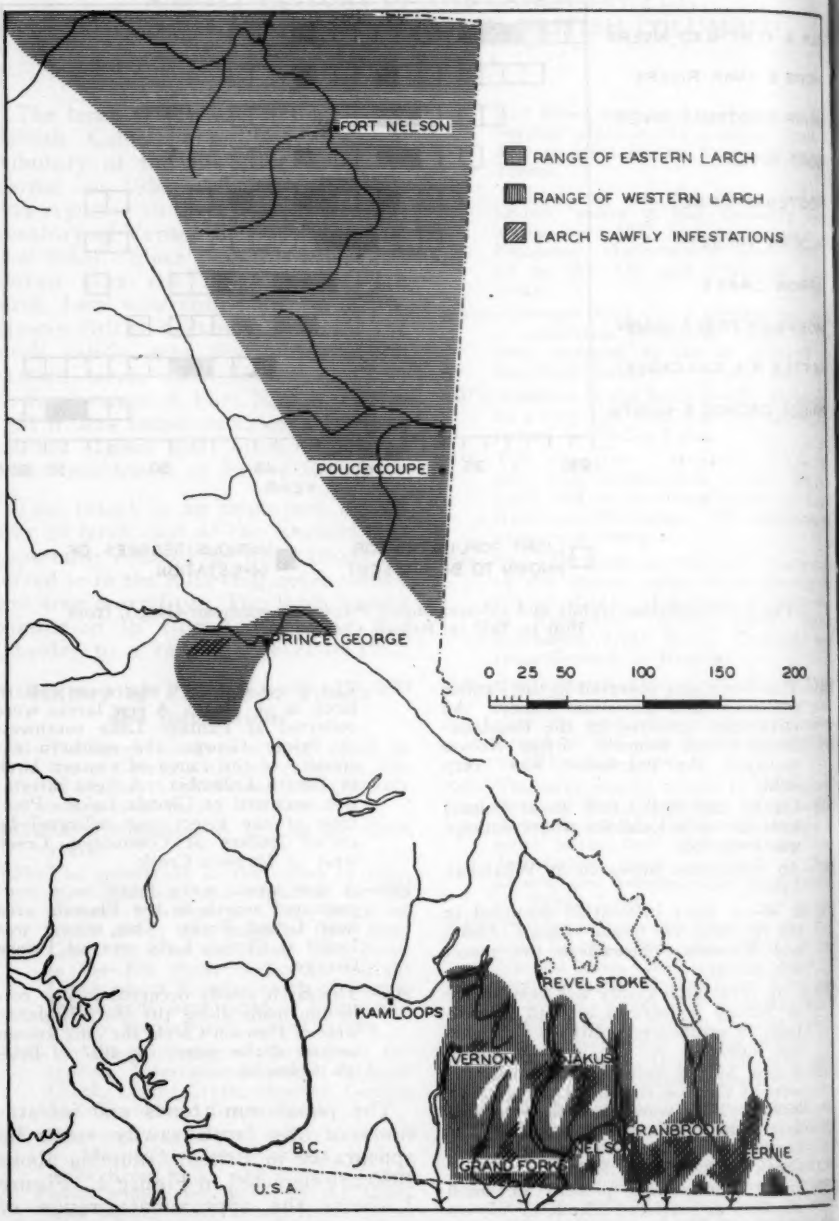

Fig. 2.—The ranges of *Larix occidentalis* Nutt., and *Larix laricina* (DuRoi) K. Koch and known areas where infestations of *Pristiphora erichsonii* (Htg.) have occurred since 1930 in British Columbia.

range where the insect has not been found. Alpine Larch, *Larix lyallii* Parl., occurs at high elevations over much of the range of western larch, but has never been recorded as a host of larch sawfly in British Columbia.

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A Record of a Sand Cricket, Stenopelmatinae, from the Coastal Wet Belt of British Columbia

The Stenopelmatinae constitute the first of five sub-families of the Tettigoniidae or long-horned grasshoppers that occur in British Columbia. Insects of this sub-family, generally called Sand or Jerusalem crickets, have enormous, smooth heads and heavily spined front legs for digging in the sandy soil in which they live. They are nocturnal, hiding by day in burrows excavated under stones and bits of wood.

In his list of the Orthoptera of British Columbia (1), Buckell records three species: *Stenopelmatus fuscus* Haldeman of which he collected one specimen from Fairview, just south of Oliver; *S. longispina* Brunner, recorded from Vancouver by Carl Brunner (in Vehr-Zoll-bot. Gesellsch. Wein XXXVIII, p. 261, (1888)), and *Cyphoderris monstrosus* Uhler, the nocturnal wood cricket which is common in the Dry Belt in the aspen groves that fringe timber line.

Specimens of *Stenopelmatus* have no traces of wings; *Cyphoderris* males have short, stub-by tegmina with which they stridulate, but the females are entirely wingless. I have taken a few specimens of *S. fuscus* from under boards near the international boundary at Osoyoos but had no record from the coast until I received a full grown specimen from Mrs. Minnie Peterson of Semiamu Bay who said it was destroying potatoes in her garden. Now this bay is given, in the Geographical Gazetteer for B.C. as "Georgia Strait East of Boundary Bay, New Westminster District" and may well be considered the Vancouver region. Therefore the specimen I received from Mrs. Peterson is probably *Stenopelmatus longispina* Brunner and it would be the first taking of this insect since 1888, the second record for the province.

I immediately wrote to Mrs. Peterson begging her to sacrifice her potato patch for the sake of science and to collect me all the specimens she could, but the first is the only one received so far; Mrs. Peterson is apparently not a scientist, or the insect is excessively rare at the coast.

Reference:

(1) Buckell, E. R. 1930. The Dermaptera and Orthoptera of Vancouver Island. Proc. Ent. Soc. B.C. **27**: p. 46.

—G. J. Spencer, University of British Columbia.

Melandrya striata Say at Vernon, B.C. (Coleoptera, Melandryidae)

The occurrence of *Melandrya striata* Say at Courtenay, B.C., has been recorded by Gregson (Ent. Soc. B.C., Proc. 41.36, 1944). The only other B.C. specimens that I have been able to locate are in the Canadian National Collection; one is from Victoria and the other is of doubtful authenticity as there is no locality on the label.

On May 16 and 17, 1950, I collected 13 larvae, 4 pupae and 5 callow adults of this beetle from stumps of white birch *Betula papyrifera* Marsh, 8 miles east of Vernon, B.C. The larval galleries were traced to a depth of 4 inches in the rotting wood, but the pupal cells were mostly within an inch of the surface.

—J. Grant, Forest Biology Laboratory, Vernon, B.C.

A new record of *Annaphila arvalis* Hy. Edw. in British Columbia

I took a fine specimen of *Annaphila arvalis* in Saanich, Vancouver Island on March 10, 1958. This appears, from my information, to be the first record since two were taken by E. M. Anderson at Goldstream, V.I., March 22, 1903.

This species formerly masqueraded as *Brephos fletcheri* in our published lists, but recent investigations have shown its real status (see Provincial Museum Report 1952).

Some doubt has existed that it was present in B.C. since no specimens had been taken for so long. Evidently it is an insect that cannot be collected deliberately owing to the fact that its habits do not coincide with our method of approach. It seems to be met with only by pure chance and good luck.

The caterpillar is known to feed on *Montia perfoliata*, therefore it should be looked for where this plant grows, but always very early in the season.

—George A. Hardy.

A NEW ASPECT ON THE FAUNAL CONNECTIONS BETWEEN EUROPE AND THE PACIFIC NORTHWEST

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Lindroth (1957) in an excellent book entitled "The Faunal Connections between Europe and North America" has dealt with the animals, especially the insects, common to the two continents. He shows that the introduction of foreign plants and lower animals in Newfoundland has been brought about, to a large extent, by their unintentional introduction in ballast. Hence there is no need to postulate land bridges, etc. This ballast was carried over in sailing vessels of the North Atlantic trade and dumped on or just off-shore from the areas in which these vessels loaded cargo for shipment to Europe. It was found that much of the ballast transported to Newfoundland originated from southwestern England.

On pp. 170-172, instances of similar ballast dumping in the Pacific Northwest are cited: one for Puget Sound and one for Portland, Oregon. Dr. J. R. Adams of the University of British Columbia tells me that Departure Bay, just north of Nanaimo on Vancouver Island, was a centre for ballast dumping: coal mined there from 1852 on was shipped to all parts of the world. Figs. 7 and 8 in Lindroth's work show the distribution of introduced species of *Carabus* in North America, and shows the area around Vancouver to be one of the primary centres. It is suggested that the ballast dumping in this area may have played a considerable part in introducing European forms to the area. Most of the European insects introduced into the Pacific Northwest have been late arrivals compared with eastern Canada; this is correlated with the fact that the Panama Canal was not opened until 1914. We do not know, at present, the place of origin of the ballast dumped in the Pacific Northwest. Perhaps much of it also came from Southwestern England.

Varley (1958) in a review of Lindroth's book, when discussing the groups of animals considered therein, states that "the vast majority of animal groups are excluded because taxomic study is insufficiently advanced, and careful collation of the described species on the two sides of the Atlantic has yet to be undertaken." The present author has collected Heteroptera in Great Britain for the past 11 years and is now undertaking such a collation in this group. Whilst collecting with Dr. W. J. Le Quesne, in southwestern England in 1956, the author took the opportunity to collect in many of the areas, mentioned by Lindroth as those from which ballast was taken.

It is of interest to note that a number of the species of Hemiptera recorded as new to British Columbia since 1914 by Mr. W. Downes are of European origin. The author hopes to be able to collect specimens and trace records of ballast dumping for the Departure Bay area. Any assistance in this field would be greatly appreciated.

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Varley, G. C. 1958. Review: Lindroth, C. H. *The Faunal Connections between Europe and North America.* Ent. mon. Mag. **94**: iii.

INSECTS CAUSING SEED LOSSES IN DOUGLAS FIR ON VANCOUVER ISLAND IN 1957[1]

A. F. HEDLIN

Forest Biology Laboratory, Victoria, B.C.

Previous work on cone and seed insects on Vancouver Island has indicated that insect-caused seed losses in Douglas fir are important (Graham and Prebble, 1941; Radcliffe, 1952). However, these studies were interrupted before a conclusion was reached.

The present study was started in 1957. The object is to determine first what insects are present and their relative importance in causing seed losses in Douglas fir. There are a number of insect species involved and it is hoped to identify at least those of economic importance. The life histories and seed-destroying capabilities will be studied and eventually experiments in chemical and cultural controls will be carried out. Thus it is hoped that it will be possible to reduce insect-caused seed losses within restricted areas, such as seed orchards.

To study cone production and seed losses on an area-basis one plot was measured out at each of four different elevations in the Cowichan River area of Vancouver Island. In each plot, potential cone-bearing Douglas-fir trees were tagged. These trees will be examined each year for cone and seed production and for records of insect losses at the different elevations. Plot elevations ranged from 400 to 1625 feet.

Biological studies were carried out by examining cones for insects and damage at regular intervals from time of pollination until cone maturity. In this way complete series of immature forms were obtained and their damage noted. In early spring, eggs were obtained and later observations yielded larvae of the different instars through to the pupal stage. Four hundred and ninety cones were dissected scale by scale.

Results

The insects of importance can be conveniently divided into three groups: seed chalcids, cone moths, and cone gall midges.

Megastigmus spermotrophus Watchl family Chalcididae

The biology of the seed chalcid *Megastigmus spermotrophus* is well known (Hussey, 1955), so little time was spent on it. The egg is laid within the young seed in the spring. After hatching, the larva feeds on the developing seed and by the time it is fully grown has devoured the inside of the seed. It remains in the seed over winter, pupates and emerges the following spring. Each insect destroys one seed.

Barbara colfaxiana (Kearf.) family Olethreutidae and other cone moths

The cone moths have received much more publicity than other Douglas-fir cone insects with the possible exception of *M. spermotrophus*. The reason for this is probably that they are larger and their feeding activities are more conspicuous than the other important species. *Barbara colfaxiana* is the species to which almost all the blame is attached. According to Heinrich (1923) there are three different forms or varieties causing damage to cones of Douglas fir and several others which attack cones of other conifers. In this study, larvae of other lepidopterous forms were obtained also, including *Dioryctria* sp. and several smaller unidentified forms.

1. Contribution No. 458, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

1. Personal communication: F. P. Keen, California Forest and Range Exp't. Stn., Lafayette, Calif., Jan. 1958.

2. Personal communication: N. E. Johnson, Weyerhaeuser Timber Co., Forestry Research Center, Centralia, Wash., Jan. 1958.

The adult *Barbara colfaxiana* emerges in March or April and lays its eggs, usually singly, on the exposed portions of the cone bracts. When the larva hatches it begins to feed on the bract tissue and migrates into the cone where it feeds mostly on scale tissue for some time. The late-instar larva feeds on scales and seeds without showing any particular preference for either. In late summer it bores a tunnel to the surface of the cone and at the same time discharges frass, which adheres to the surface of the cone in pitch. The insect then forms a tough cocoon near the axis of the cone in which it pupates. It remains there over winter.

Damage resulting from the feeding by this insect can be divided into two categories, direct and indirect. Direct damage to seeds is simply the result of feeding on the seed. This is easy to assess. Indirect damage is the effect which injury to conductive tissues may have on developing seeds. The larva wanders around in the cone and obviously the damage to surrounding tissue will affect neighbouring seeds. The extent of this type of damage is more difficult to assess. Radcliffe (1952) found a significant difference in seed-viability between seeds from infested and uninfested cones. When only one larva is present a cone may develop quite normally, but when several are present the apical half of the cone is often killed before maturity. In 1957, 23 per cent of the cones in plots were infested with *B. colfaxiana* and the average direct damage was 3.6 ovules and 1.9 scales per cone. The average damage to ovules in one severely infested tree was 9.6 per cone.

TABLE I.—Percentage Douglas-fir cones infested with cone moths and gall midges.

Location	Elevation	No. of trees Total	Produced cones 1957	Percentage cones infested Cone moths	Gall midges
Plot 1	1625	33	7	50	32
Plot 2	1300	42	11	8	11
Plot 3	925	41	5	0	62
Plot 4	400	60	4	20	90

The Cone Gall Midges, Family Cecidomyiidae

The third group comprising the gall midges of the family Cecidomyiidae has received little attention, but some of its members are very destructive. Graham and Prebble (1941) recognized their potential as seed-destroyers but little mention has been made of them since. Some of the species occurring in Douglas-fir cones have been described by Foote (1956) but there is still uncertainty as to identification of some species. Keen[1] states "there are at least four species of gall midges (Itonididae) found in Douglas-fir cones and possibly more." The one which causes most damage lays its eggs in clusters near the base of the scales of the young cone. When the eggs hatch, the young larvae enter the soft scale tissue and form a polythalamous gall which usually destroys the seed. When few larvae establish themselves, the seed may form but becomes fused with the scale, and is not released from the cone. In the fall the larvae leave the cone to enter the duff, and emerge the following spring. Under natural conditions pupation probably does not occur until spring.

Gall midges infested 33 per cent of the cones in the plots and caused an average of loss 4.4 seeds per cone. The maximum seed-loss recorded in one cone was 32. Infestation of cones ranged from 11 to 90 per cent in different plots. Johnson[2] reported these insects to be serious in the State of Washington also.

Discussion and Summary

This study is aimed at separating the different species and their damage, working out their life histories, and determining a means of control for the important species in seed orchards. It is difficult to draw definite conclusions following only one year's work. However, it is apparent that a number of insect species are involved and that some of these are potentially capable of destroying appreciable amounts of Douglas-fir seed.

In 1957, seed chalcids, cone moths, and cone gall midges were present in appreciable numbers with the latter being the most important single group.

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Two remarkable Moth Chrysalises

Towards the end of May 1925, I received from the government fumigation station in Vancouver, four sapling Chinese elms with curious hard lumps projecting from the stems. The lumps were smooth, oval, nearly ½ inch long by 5/16 inch wide, striped with six alternate brown and white longitudinal bars and were stuck tightly to the stems. I had an idea that they were of lepidopterous origin so kept them in the laboratory.

On June 20 when working at a table I heard a curious little "plop!" and immediately something flashed to the window which fortunately was closed, and banged up against a pane. It was a stout-bodied brownish-orange-yellow moth with a wing spread of about 1¼ inches. Closely watching the other lumps on the stems, I was fortunate enough to see the emergence of another moth; suddenly the rounded top of the chrysalis, like an operculum, flew off with a click and in one fluid movement, without the pause for wing expansion and drying common to most moths, this one emerged from the chrysalis and flew straight towards the light, to hit the window with a thud.

Having no references to Chinese insects, I consulted Maxwell Lefroy's "Indian Insects" and found an illustration and brief description of a very similar moth; it belongs to the Limacodidae, closely related to the Eucleidae or flannel moths which have caterpillars with extremely irritating spines.

In the Blackmore-Wynne collection of Lepidoptera at the University, are specimens of only one species of Limacodidae in this Province, *Tortricidia testacea crypta* Packard, from Saanichton and Enderby, with no notes about its chrysalis.

The emergence of these moths from their hard chrysalises is so remarkably swift as to raise the question "Why?". Every other moth that I have ever heard of or seen takes some little time for the expansion and drying of its wings and the large silk worm moths take several hours. Against what enemies or danger is this moth so protected that it emerges from its chrysalis like a jack-in-the-box?

The second remarkable chrysalis was brought to my attention by Mr. F. Jackson, 440 E. 35th Avenue, Vancouver, who rang me up in June 1957 to ask "What insect is made of gold?" As usual in such cases, I said that I did not know but to send in specimens. In a few days he sent some withered leaves tied into clumps with scanty silk and showing in spots, touches of gold. On tearing open the leaves I was amazed to find small obtected pupae of pure, polished gold, the most beautiful things imaginable. For once a citizen was correct, they *were* of gold. From July 2 to July 5, four moths emerged from these pupae leaving behind them delicate empty cases with only the faintest tinge of gold. The moths are geometrids *Sicya macularia crocearia* Packard and from the Blackmore-Wynne collection I find that they are quite commonly distributed at the coast and at Enderby where Mr. Wynne lived, and in the southern interior. Larvae of the form *macularia* are recorded by Llewellyn Jones as feeding upon *Acer, Betula, Vaccinium, Spirea, Pinus contorta, P. monticola* and *Tsuga,* a very wide range of food plants. It would be interesting to know if all the pupae from larvae that feed on such diverse hosts have this polished gold reflection.

The moths, nicknamed "Pink-bordered Yellow" by Blackmore, possess none of this metallic sheen; and the nickname indicates, the colour is yellow with a pinkish-brown margin on the front wing. I can find no references accounting for metallic gold in insects. Other colours, especially yellows, are accounted for by pigments and environmental factors, but not gold. The gold in these pupae may be pigment, rendered metallic by interference lines, that emerges in the adult wing as yellow.

Finally it is of interest to note that the word "Chrysalis" comes from the Greek "Khrusallis" meaning "golden thing". Did the first entomologist-etymologist to employ that word *Chrysalis* to the obtect pupae of Lepidoptera, have before him the metallic golden pupa of this insect *Sicya macularia*? —*G. J. Spencer, University of British Columbia, Vancouver.*

ANNOTATED LIST OF FOREST INSECTS OF BRITISH COLUMBIA PART VIII — *SEMIOTHISA* SPP. (GEOMETRIDAE)[1]

D. A. ROSS[2] and D. EVANS[3]

The larvae of *Semiothisa* spp. are leaf eaters; seven of the forest species feed on conifers, three on deciduous-leaved hosts. None has been known to occur in destructive numbers in British Columbia. The larvae are medium-sized loopers: some species are green with white stripes, a few have two colour phases. All species overwinter as naked pupae in the duff.

S. adonis B. & McD. *Pinus ponderosa, P. contorta, P. monticola, Pseudotsuga taxifolia* (3), *Larix occidentalis* (1); southern B.C.; rather uncommon. **Larva:** 1⅛ inches; head, pale green, dull reddish patch above and before ocelli; body, green; cream-coloured subdorsal stripes (includes abdominal setae ii of Dyar and Forbes) continuous onto the head; broader cream subspiracular stripe.

S. granitata Gn. *Pseudotsuga taxifolia, Picea engelmanni, P. glauca. P. mariana, P. sitchensis, Tsuga heterophylla, Abies lasiocarpa, A. grandis, A. amabalis, Pinus contorta, P. monticola;* believed to be accidental on *P. ponderosa* and *Larix* spp. Generally distributed; sometimes very numerous over small areas. In 1949 numerous adults emerged during early fall; normally the species overwinters in the pupal stage. **Larva:** 1⅛ inches; head, greenish, with dark reddish-brown blotch or herringbone pattern on sides, occasionally also on vertex; body, green; middorsal area dark; white subdorsal stripe ventrad of setae ii; whitish "bloom" over dorsum; fine blackish lines on dorsum, below subdorsal stripe and on subventer (these blackish lines may be obscured by the "bloom"; cream spiracular- subspiracular stripe; white lines on venter.

S. perplexa McD. *Pseudotsuga taxifolia, Picea engelmanni;* southern Interior with a few records along the southern and central Coast. **Larva:** apparently similar to *S. granitata.*

S. sexmaculata Pack. *Larix occidentalis, L. laricina;* southern Interior on western larch and central Interior north into the Yukon on eastern larch; frequently numerous. Sometimes this species has a partial second brood. **Larva:** length ¾ inch: **green phase** — head and body green; white addorsal lines dorsad of seta i; broader white subdorsal stripe ventrad of ii, bordered below by black line; cream subspiracular stripe; white midventral and subventral lines; no black lines on venter; **brown phase** — head, off-white, with brown blotch or herringbone pattern on vertex; body, off-white, overlaid with brown; irregular broad anteriorly directed dark brown wish-bone mark on the dorsum of each abdominal segment.

S. triviata B. & McD. *Juniperus scopulorum;* Australian, Marguerite, Alexandria, Williams Lake, Mara Meadows, Fort Steele, Hedley. **Larva:** ¾ inch; head, off-white with irregular brown patch through setae ii (Dyar); pale herringbone pattern on vertex;

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frons black; body brownish; small off-white subdorsal patches at anterior margin of each body segment; black irregular V patch containing each abdominal spiracle continuous forming V's on venter of abdominal segments; off-white patch anterior to each spiracle.

S. teucaria Stkr. *Quercus garryana;* southern Vancouver Island. **Larva:** ¾ inch; dull lime-green, wide pale subdorsal stripes; yellow spiracular line; ventral and anal prolegs marked with crimson.

S. setonana McD. *Juniperus scopulorum;* southern Interior. **Larva:** 1 inch; greenish head, may have light brown herringbone pattern; white patch on either side of frons containing scta ii (Dyar); body, green (apparently there is also a grey phase); subdorsal stripe broken, irregular; small blackish spot at intersegmental area on dorsum; black V patch through spiracles; white patch anterior to spiracle and rusty patch below; four white lines on venter.

S. neptaria Gn. *Salix* spp.; southern and central Interior, Vancouver Island. **Larva:** 1 inch; head, reddish brown with curved brown band above frons; body, yellow-brown; broken white addorsal lines; brownish patch under abdominal segment 2.

S. hebetata Hlst. *Salix* spp.; Canal Flats, Connell Creek, Manson Creek, LeJeune Lake and at various points in the Yukon between miles 916 and 1190 on the Alaska Highway. **Larva:** 1 inch; head, brownish with black transverse lines above and below frons; body, dark purplish-pink with banded appearance; broken, off-white or yellowish addorsal line and subspiracular stripe; blackish patches about spiracle.

S. continuata Wlk. *Tsuga heterophylla, Thuja plicata;* southern Coast. **Larva:** ½ inch; head, large and green; body, bright green with cedar-twig-like pattern; broken white lines; pale spiracular line.

BOOK REVIEW

Annual Review of Entomology, Vol. 3. (*E. A. Steinhaus* and *R. F. Smith,* editors). 1958. Annual Reviews, Inc. Palo Alto, Calif., pp. vii - 520.

A slightly astringent reviewer of entomological books for the Quarterly Review of Biology, Prof. George C. Wheeler, complained (*Ibid* 32 (2): 191)) that Vol. 1 of this series "might have been more appropriately entitled an 'Annual Review of Applied Entomology' since 70 per cent of its pages are devoted to that branch". His criticism is no longer valid; Vol. 2 had about 45 per cent economic content, and Vol. 3 has a mere 30 per cent. In this reviewer's opinion, the balance is now about right. Much of the support for the parent society and the Annual Review comes from applied entomologists, entitling them to their one-third share, even to the section on air-blast spraying which seemed particularly to irritate the critic mentioned. Since some of the best current work is applied, or at least economically motivated, the editors can scarcely reduce the economic papers below their present level and still claim to represent the profession.

The volume seems to be top-heavy with U.S. contributions in the proportion of 15 to 8 for the rest of the world. Origins of the latter are: the U.K. 3, Canada 3, Australia 1, and France 1. The non-English speaking world seems to be poorly represented. Of the 64 papers in the first 3 volumes, only 2 have come from Continental Europe, none from Scandinavia, India or Russia. Would not an occasional review by region as well as by topic be acceptable? A chapter entitled, for example, Entomology in the U.S.S.R. would be read with considerable interest.

Two minor irritants persist in Vol. 3, both concerning the citation of literature. In soliciting a review, could not the editors suggest that the names of authors cited be left out of the text, except when discussing differences of opinions as in A. J. Nicholson's "Dynamics of Insect populations"? The text is more swiftly read without them, and the reputation of the reviewer himself should be the guarantee that only the best contributions in the field are being surveyed. The second criticism follows from the first.

In a review, the sources are of prime interest, hence it is no more than courteous to list them alphabetically so that they are quickly available. Fortunately, only 9 of the 23 reviews have non-alphabetic references, not including the largest list with 285 titles.

The authors and topics for Vol. 4 have been announced. It appears that the high standards are to be maintained.

H. R. MacCarthy.

Printed by
CHAPMAN & WALWICK LTD.
VANCOUVER, B.C.